Thermodynamic Isolation and the New World Order

Peter Pogany

Shenandoah Valley Research Press

17. September 2013

Thermodynamic Isolation and the New World Order

Peter Pogany

Abstract

The general stream of economic thinking is thoroughly a-physical and a-historic. This direction is becoming increasingly absurd as the nexus between the human biomass and its ecological constraints ripens. Economics will eventually have to absorb apodictically that regardless of scientific-technical development and the intensity of entrepreneurial drive, the aggregate, long-run supply of telluric substance-borne free energy is on a path of declining elasticity. To hasten recognition, it would be helpful to consider the Earth an isolated, rather than a closed thermodynamic system. From the perspective of its evolutionary potential, the world is indeed *Under the Dome.* This paper argues that (a) the emergence of classical capitalism in the 19th century answered the need for global-scale self-organization; (b) this scheme, interrupted by World War I, was replaced after World War II; (c) the implied transformation has been accompanied by a nonarbitrary, causally determined, irreversible socialization of intranational and international economic relations; (d) contemporary civilization is moving toward a new form of self-organization that would recognize limits to demographic-economic expansion. What will it take to go from the current hostile disgust with the dystopia of tightened modes of multilateral governance to people around the world on their knees begging for a planetary guild? It will take nothing less than a mutation in consciousness, as outlined in the oeuvre of Jean Gebser (1905-1973).

Contents

1. Introduction

Orthodox economics assumes a self-adjusting relationship between the economic process and its material resources. This credo of ecological independence, which is logically consistent with existing institutions, social life, politics, culture, and ethics, now faces the censorships of reality.

The world will not (because it cannot) be turned into a shopping center for 10 billion people with ample parking for their 2.5 billion motor vehicles by 2050. Predictions that the global economy will double its current size by 2030 (a projection that follows from the widely used 4-percent annual growth of the GWP through this and the next decade) are dead in the water.[1]

If the planet's economy operated at the full-employment rate of its currently available resources, or if it would make significant strides toward it, the phenomenon of Nature applying brakes on the human enterprise would be quite obvious. Only relative sluggishness dulls and slows the already unfolding clash between our civilization and its

[1] Meadows, Meadows, Randers, and Behrens (1972) planted and Meadows, Meadows, and Randers (1992) rekindled the scale limit problematic. The immune system of established economic ideology rejected both publications with vexatious derision.

physical constraints. But reckoning with a historic no-exit situation is clearly on the horizon. The prevalent form of economic organization, which cannot survive without accelerating output levels, tends to activate its inhibiting antidotes: rise in the cost of nonrenewable resources (oil and industrial metals chief among them)[2] and in the likelihood of punishing environmental mishaps.[3]

---

[2] James D. Hamilton's econometric work has convincingly demonstrated the causal role oil price hikes have played in triggering worldwide economic setbacks in the wake of Middle Eastern crises and OPEC embargoes. The plasma role image of crude oil in the global economy was made even clearer by evidence that sky-rocketing oil prices (explainable by excess demand) played a major role in the recession of 2007-2008, as well:

http://www.voxeu.org/article/did-rising-oil-prices-trigger-current-recession

"Oil Prices, Exhaustible Resources, and Economic Growth" (a chapter prepared for the *Handbook of Energy and Climate Change*) by the same author details the reasons why the economic (and hence geopolitical) consequences of the inevitably approaching stagnation and decline in oil production are likely to be severe:

http://dss.ucsd.edu/~jhamilto/handbook_climate.pdf

Keith Sill elaborated on the evidence that oil price increases lead to economic slowdown:

http://www.philadelphiafed.org/research-and-data/publications/business-review/2007/q1/br_q1-2007-3_oil-shocks.pdf

The UK-based New Economics Foundation (NEF) equated the upward-trending marginal cost of oil production with a glass ceiling on economic growth:

http://dnwssx4l7gl7s.cloudfront.net/nefoundation/default/page/-/files/Glass_ceiling_webReady_.pdf

Two IMF working papers bolster the conviction that the world faces an oil predicament:

http://www.imf.org/external/pubs/cat/longres.cfm?sk=25884.0

http://www.imf.org/external/pubs/cat/longres.aspx?sk=40066.0

Kurt Cobb poignantly commented on the two papers:

http://www.resilience.org/stories/2012-11-11/does-the-imf-believe-we-have-a-peak-oil-problem

The marginal cost of the following metals threaten to escalate in the foreseeable future: "Precious metals," i.e., Silver, Gold, and the platinum group (Ruthenium, Rhodium, Palladium, Osmium, Iridium, in addition to Platinum); "minor metals" Gallium, Germanium, Indium, and Thallium; the "tungsten group" (i.e., Tantalum, Zirconium, Niobium, and Molybdenum, in addition to Tungsten) and the 15 Lanthanides ("rare earth elements"). The economic significance of this list can hardly be overestimated. As alloys, catalysts, and components, these elements are indispensable in the production of structural materials, computers, a wide range of industrial goods, household appliances, medical and optical products, transportation, space-engineering, and defense equipment. For details on the depletion of industrial metals in the broad context of limits to economic expansion, see Diederen (2010).

[3] Gore (2013) demonstrates the imminence of experiencing the consequences of environmental abuse.

To assess the future without Pollyannaish subterfuge, the planet's thermodynamic isolation ought to be considered a self-evident axiom. (Stephen E. King's symbolic energy field that came down on a single locality in his novel envelopes the entire world -- menacingly as well as protectively, like the trusted walls of a *Domus*.[4]) This is the paper's *thema probandum*. Supporting arguments are summed up in Section 2.

Section 3 presents a rudimentary, quantitative platform for the proposition that the sum of free (available) energy contained in earthly matter undergoes an accelerated qualitative degradation. Indeed, it is a complex sponge of gradients that can be squeezed only once. The global community's downhill movement on the free energy hyper-plane is referred to as the *Drawdown* throughout the paper. The aside on Saint Anselm was motivated by the idea that even the best cause needs propaganda: To associate the entropy law with the ethical imperatives of a new, long-run-equilibrium-seeking *Weltanschauung*, it needs to be adjudicated thoroughly and repeatedly.

Section 4 intends to demonstrate how wrong-headed modernity's intrinsic assumption is; namely, that thanks to man's engineering genius and entrepreneurship, the enormous amounts of energy the sun radiates to the planet, and the indestructibility of matter and energy, the global economy does not have a scale limit. It can grow forever as if propelled by an invisible *deus ex machina*. The deep root of this conviction is an unrecognized fallacy of composition: Average consciousness (i.e., the world at large) implicitly extends the individual's thermodynamic openness (a biological necessity) to the terrestrial sphere.

Section 5 spells out that meta-history (or universal sociological history) is an epiphenomenon of the thermodynamically dissipative process represented by the combined demographic-economic expansion. The "steady state -- bifurcation -- steady state" sequence characteristic of such processes may be recognized by considering "1914-1945" the chaotic transition that led from the world's first global system, *laissez faire/zero multilateralism/metal money* (GS1) to the second and current one, *mixed economy/weak multilateralism/fractional reserve money* (GS2). Examples illustrate how widespread chaotic transitions are in Nature. The reason for this special emphasis is that the world faces (or is already involved in) another turbulent macrohistoric interlude as it strains toward a third, hypothetical global system (GS3): *two-level economy/strong multilateralism/mostly government money* (*maximum reserve banking*).

Given the insolvability of the aggregate scale problem within the parameters of the prevalent socioeconomic order; and that the system with a truly macroscopic, empirical approach capable of solving it is abhorred on sight, one can reasonably predict the coming of a universal crisis of consciousness. This is the subject of Section 6. It centers on the teachings of Jean Gebser (1905-1973).[5] Section 7 offers a few parting thoughts.

---

[4] The Delphic sight with which a consummate artist can transcend the world's disorderly, confusing progression is a mysterious, reassuringly perennial trait of human intelligence.

[5] Pogany (2012) and the following two working papers maintained at MPRA are dedicated to the same theme:

2. Basics of thermodynamic reality

2.1. GLOPPE

The *global population plus its economy* (GLOPPE) is the combined substance of the human biomass, other life-forms in human service, and objects created through the economic process. Although at first glance it may seem demeaning to generalize to the point where the difference between *Homo sapiens*, a goat, and a toaster vanishes, without making this gigantic, restless organized lump of matter the center of analysis, the world as a biological and socioeconomic phenomenon, with a powerful and (as it will be argued) unstoppable momentum, is reduced to a multiplicity of meaningless perspectives gained by staring through knotholes.

GLOPPE is a life phenomenon. Thus, it is not "unnatural" in the sense Rudolf Clausius (1822-1888) used the expression to characterize the transformation of heat into work by combustion engines. *Au contraire*! Like electricity, life appears whenever its physico-chemical conditions come together. The close proximity of zinc, carbon, and acid will make electrons flow; that of atmosphere, liquid water, certain elements and physicochemical stability will create a natural flux of energy we call life. Since life subsumes the urge to improve the quality of living, GLOPPE may be considered to be thermodynamically spontaneous even if it is manifest in innumerable non-spontaneous activities, as the multiplication of individuals and the fabrication of use values make it perfectly obvious.

Physics attributes spontaneous processes to the eternal thermal agitation of molecules, atoms, and subatomic particles. The question as to how this technical definition could apply to purpose- and rationality-suffused GLOPPE may be answered this way: Chance fluctuations in the brain would like to make cerebral matter and the rest of the body spread out in space, thereby increasing disorder in accordance with the second law of thermodynamics (*second law*). However, the solid contours that define the organism force Nature's primordial entropic drive to follow a complex, indirect strategy. The pockets of order created by the conscious, willful bustle of an ever larger and better organized human biomass will be exceeded by the disorder this phenomenon generates in its surroundings. ("Does intelligent life throughout the cosmos represent an effective strategy of Nature to hasten the restoration of thermodynamic equilibrium in the universe?" Who would dare to answer this question with a claim of credible objectivity? But it seems that *la promesse de bonheur* is the entelechy-carrot and *la joie de vivre* the weekly compensation for an existence that we cannot "rationalize" without committing "philosophical suicide" -- to use Albert Camus' expression.)

To comprehend the practical consequences of GLOPPE's thermodynamic spontaneity, it is essential to have a realistic idea about the medium in which the demographic-economic expansion unfolds.

---

http://mpra.ub.uni-muenchen.de/27221/1/MPRA_paper_27221.pdf

http://mpra.ub.uni-muenchen.de/cgi/users/home?screen=EPrint%3A%3AView&eprintid=39056

2.2. Terrestrial Sphere

The distance between the Earth's center and its surface at the equator is 3,963 miles. This is the longer way. Going poleward to the surface, the distance is 3,950 miles. If we continued along this radius 6,000 miles straight up, we would be well into the exosphere, where the veil of gases surrounding the planet begins to fade into the interplanetary vacuum. The radius of this sphere is 9,950 miles, roughly 10,000 miles. We can call the imaginary spatial figure, which has a diameter of 20,000 miles, the *Terrestrial Sphere* (*Sphere*). Some stray atoms of hydrogen and other light gases escape from its area into outer space, and meteors and cosmic dust enter it. However, the weight of the mass leaving and entering is negligible compared to the total weight of mass contained in it.[6] With regard to matter, the *Sphere* is virtually closed. The atoms it contains can be broken down into elements or ensembles of elements, such as metals, semimetals, and nonmetals, or minerals and nonminerals. Oxygen is the predominant element. In volume, it is followed from a great distance by potassium, sodium, and calcium. In weight, it is followed somewhat more closely by silicon, aluminum, and iron. For all intents and purposes, the *Sphere*'s inventory of atoms is constant.

What kind of thermodynamic system is the *Sphere*?

Modern thermodynamics distinguishes among three kinds of systems: Open, closed, and isolated (Kondepundi and Prigogine, 1998, pp. 3-7). An open system exchanges both energy and matter, the isolated system exchanges none of the two; and the closed system exchanges one of the two with its surroundings. According to these definitions, the *Sphere* is a closed system. It exchanges energy with the exterior (solar radiation, re-radiation) but not matter. Whatever we do with earthbound substances, incorporating them into our bodies, using them as raw material; discarding the bodies, throwing away or reusing matter over and over again, the weight and composition of atoms remain unchanged in the *Sphere.*

GLOPPE's energy comes from absorbing solar radiation and sucking free energy from material structures found in the *Sphere*. Material is the tight constraint. A closer examination of this proposition begins by accepting that GLOPPE is subject to the laws of thermodynamics.

The first law of thermodynamics (*first law*) guarantees that matter in the *Sphere*, whatever happens to it, will not be destroyed. The *second law* is much less reassuring. It informs us that GLOPPE is dissipative. The two main interpretations of the *second law* are "inevitable waste" and "increasing disorder." The first refers to the fact that heat gained from the internal energy of matter cannot be transformed into mechanical energy with one hundred percent efficiency (work output/heat input is always smaller than one). The second interpretation states that disorder in an isolated system tends to increase. It is exactly this second interpretation that allows conventional economics to wipe "entropy"

[6]The mass of the Earth is estimated to be 5.97 x 10^{18} tons. Since this calculation was based on the Earth's radius, the *Sphere*'s mass must be greater than this figure.

from its list of preoccupations: "Entropy increases in an isolated system, but not in a closed one"[7]

Samuelson (1948), the quintessential background study of GS2's *text*,[8] sets the limits of according consideration to thermodynamics in postwar economic ideology. It invokes *Le Chatelier's Principle* as Nature's physical approximation of a self-equilibrating market economy (*op cit*. pp. 36, 38 n. 81, and 168).

In perfect harmony with the dogma of open-ended acceleration as *the* equilibrium, economics textbooks generally avoid the *second law*, although adhering to this "party line" has become next to impossible in teaching courses on natural resource/environmental and ecological economics. References to entropy in this domain vary from stating the issue correctly without dwelling on its monumental significance (Daly and Farley, 2004); or describing it with succinct accuracy and then forgetting about it (Pearce and Turner, 1990); to presenting a formal argument against irreversible entropic accumulation based on a vague thermodynamic characterization of the *Sphere* (Common and Stagle, 2005).[9] In general economic literature, however, proofs and demonstrations of the *second law*'s relevance to the economic process continue to emerge. (See, for examples, Krysiak, 2006, and Jing Chen, 2005).

2.3. The world's *de facto* isolation

Given the uniformity of the Earth's solar-lunar environment, the *Sphere* ought to be considered an isolated thermodynamic system in order to put structure-borne free energy into the relief it deserves.

This apophantic proposition ought not to be shocking. Isolation is never perfect (e.g., gravity and electromagnetic forces penetrate even thermoses). Declaring a system to be sealed off always rests on factors deemed to be relevant from some empirical vantage point. Since GLOPPE is a function of a diminishing terrestrial and a constant extraterrestrial (solar-lunar) flow of energy (and importantly, the second kind cannot be used without drawing from the first kind), the dynamics of our world is better analyzed by focusing on the time-dependent variable. Perspicuously, the international scientific community needs to acknowledge that, as a mirror process to GLOPPE's growth, the *Sphere*'s totality of *res extensa* (its corporeal substance with chemical potential) has a quantitatively expressible quality that tends to diminish over time. It is a simple thermodynamic fact that the expansion of metabolic exchanges within an isolated system is endogenously constrained and eventually quenched.

The "macro" perspective

[7] Rudolf Clausius invented the word "entropy." He took "trope," which is Greek for transformation, the core of the concept, and sandwiched it between the prefix "en" and the suffix "y" (cf. Cropper, 2001, p. 101).
[8] *Text* is the catechism-like summary of a global system's economic blueprint. See section 5.
[9] See more on the subject of falsifying global thermo-dynamicity under section 4.

The Earth, the Moon, and the Sun together form an isolated thermodynamic system. Although it is, in fact, more isolated than the best thermos, the great distances between these heavenly bodies prevent the formation of the mental image of isolation. Therefore, to see the human condition with greater clarity, it may be suitable to consider the Sun's presence on Earth, as well as the Moon's gravitational bounty, as if they appeared on the *Sphere*'s imaginary enveloping surface (on the *Dome*).

According to this perception, solar radiation does not travel 93 million miles in 8.3 minutes but it is here permanently with the same strength. The average perpendicular radiation per unit of time and surface at the mean distance between the Sun and the Earth, the so-called "solar constant," is a stable, geological fixture of life on Earth, allowing the flow of sunshine to be regarded as a fund-service with the characteristics of being inexhaustible, non-stockpilable, non-materially incorporated, nonexcludable, and contingent on a non-arbitrary rate of use.

Visualizing the circumference of the *Sphere* as the loci from which solar rays originate (along with the Moon's gravitational effect) and where the remainder of returned infrared radiation sinks into oblivion, helps the mind to accept the simple fact that GLOPPE expands in a thermodynamically isolated niche. For the price of taking our optical illusion of solar and lunar nearness at face value we purchase thermodynamic reality. The deal is similar to accepting the Earth's flatness within a playing field.

The "micro" perspective

The free energy endowment of the *Sphere* (Ω) maybe seen as an exhaustive trichotomy: Category I (Ω_1) is solar radiation; Category II (Ω_2) is matter that depends operatively and continuously on a dynamics with Ω_1; e.g., the atmosphere, land and water surfaces that facilitate and drive the water, nitrogen and carbon cycles. Category III (Ω_3) is matter in the maintenance of which the Sun's presence plays a passive role. Most substances labeled as "nonrenewable resources" (e.g., metals and fossils) belong to this category. Without the Sun these resources would not exist but their endurance over geological timescales proves that they are independent of the Earth-Sun dynamics as observed over historical timescales.

Theoretically, weightless Ω_1 may be converted into mass ($e = m c^2$) but there is no technique available to put this equivalence into practice. Until extraterrestrial matter is captured, the world's working substance is "$\Omega_2 + \Omega_3$" -- *punctum*.

Transformations occur between these two categories but their sum is constant at a given moment. Viz. the *Sphere* is isolated from contact with any other system that contains free energy and GLOPPE is moving the *Sphere* toward thermodynamic equilibrium. To repeat, Ω is the sum of two constants and the continuous interaction between Ω_1 and the ensemble of free energy enclosed in substances ($\Omega_2 + \Omega_3$) signifies an openness that is strictly internal to the *Sphere*.

Thinking about the *Sphere* as a closed system leaves the world's thermodynamicity open for dispute, engendering disconnected (isolated) views about the future. Considering the *Sphere* isolated ends the controversy, allowing global society to comprehend its true condition integrally.

3. Analytical approach to the *Drawdown*

If we define GLOPPE as the "system," the *Sphere* minus GLOPPE's matter the *Surroundings*, and consider the manifold activities in which the system engages the *Surroundings* purely mechanical work, the *first law* says:

(1) $$\Delta U\ (\textit{Sphere}) + \Delta W\ (\text{GLOPPE}) + \Delta W\ (\textit{Surroundings}) = 0$$

where ΔU (*Sphere*) is the change in the *Sphere*'s internal energy (potential energy contained in the chemical bonds of its molecules, equivalent *in toto* to the energy required to create the *Sphere*); ΔW(GLOPPE) is the amount of work GLOPPE performs on itself during the same period (e.g., reproduction of humans and animals in human service; simple replacement of used up capital goods), and ΔW(*Surroundings*) is the work GLOPPE completes on the medium against which it expands (e.g., adding to the human biomass, making barren lands arable, extracting petroleum and natural gas).

Remembering that an exact correspondence exists among measures of energy, heat and work (all expressible in joules), the *first law* may be applied to the thermodynamic interactions that result in GLOPPE's existence and expansion in the following way:

(2) $$\Delta Q = \Delta U\ (\text{GLOPPE}) + \sum \Delta W$$

where ΔQ is the heat added to GLOPPE (by solar radiation and by sucking free energy from the *Surroundings*); ΔU (GLOPPE) -- henceforth ΔU -- denotes change in GLOPPE's internal energy (e.g., starch accumulates in corn kernels, photosynthesis); and ∑ΔW is the work GLOPPE does, once again on itself and on the *Surroundings* combined.

So far, the application of the *first law* did not take the thermodynamic isolation of the *Sphere* into account. Without such consideration equations (1) and (2) appear to be solely the expressions of the "no-free-lunch" principle.

The full appreciation of the *first law* requires a notice of the conservation principle; i.e., that in an isolated system neither energy nor matter (as a form of energy) can vanish. Indeed, the number of atoms in the *Sphere* remains the same regardless of GLOPPE's fate. The sum of free and bound energy is constant. But whereas the *first law* reminds us that not even the enormity of solar and substance-contained free energy may be translated into a *perpetuum mobile*, the *second law* conveys an additional, profoundly important warning: *The ratio of bound energy within the total* (*i.e., the sum of bound and free energy*) *grows irreversibly.*

Let us shine a beam of light on thermodynamic reality by comparing GLOPPE to the rusting of iron.[10]

Iron symbolizes the preconditions of life (including photosynthesis[11]) in this analog and the dispersed oxygen molecules in the surroundings stand for the totality of terrestrial matter. The reaction between dispersed oxygen gas and solid iron molecules reduces entropy since the resultant iron oxide (rust) has a relatively solid structure. This is possible only by an increase in the surroundings' entropy through heat release, to an extent that exceeds the entropy reduction caused by rusting. The process is spontaneous and, accordingly, exothermic. But unlike for GLOPPE, entropy reduction and the overall greater increase in entropy in the immediate space are measurable along the macro-coordinates of pressure and temperature.

Since the free energy feeding GLOPPE may be regarded as heat transfer under constant atmospheric pressure, the examination of the *second law*'s effect may proceed by leaning on the concept of enthalpy (H).

H is a state variable indicative of a system's thermal energy, its thermodynamic potential. It is the sum of the system's internal energy and the energy required to allow it to exist by exerting pressure (P) to maintain volume (V):

(3) $$H = U + P.V$$

Given that assigning numerical values to a system's energy contents is an unsolved problem, actual calculations aim at estimating changes in enthalpy under constant pressure:

(4) $$\Delta H = \Delta U + P.\ \Delta V$$

Increases in the entropy of the *Surroundings* may be expressed with the help of alterations in GLOPPE's enthalpy as follows:

(5) $$\Delta S\ (\textit{Surroundings}) = - \Delta H\ (\text{GLOPPE}) / T$$

where T is the absolute temperature (Kelvin scale) at which the process takes place.

Since theoretically, alteration in GLOPPE's enthalpy is the sum of enthalpies contained in GLOPPE's components minus the sum obtained by adding up the enthalpies of material inputs ("products" and "reactants" in thermochemistry), ΔH (GLOPPE) may be expressed in the following way:

[10] The example closely follows Gillespie, Humphreys, Baird, and Robinson (1986), pp. 880 and 881.
[11] In compliance with the *first law*, plants convert solar to chemical energy, and the amount of energy included in the matter used by plants remains unchanged as the seasons pass. The *second law* may be recognized in the qualitative degradation of the matter involved; in the inefficiency of energy conversion as well as in the loss of energy plants give off as heat.

(6) $\Delta H\ (\text{GLOPPE}) = \sum H\ (\text{GLOPPE components}) - \sum H\ (\text{Material inputs})$

As a manifestation of the *second law*, the absolute value of the first term must be smaller than that of the second; that is, GLOPPE releases more bound energy into the *Surroundings* than the amount of free energy it sucks from there during a given period: $\Delta H\ (\text{GLOPPE}) < 0$.

GLOPPE performs work by pushing back, compressing the *Surroundings.* The negative sign of $\Delta H\ (\text{GLOPPE})$ implies an exothermic (heat releasing) process. More precisely, GLOPPE exhibits net exothermicity. While it is also endothermic by taking heat (free energy) from the *Surroundings*, it releases more heat into it (bound energy). Nonetheless, global warming, a well-documented side effect of human expansion, indicates that some of the bound energy GLOPPE releases is, in fact, heat.

Over a short period, GLOPPE's expansion is isothermal. In this case, the work performed (W) in the process of increasing its volume from v to V, under pressure P, may be conceptualized with the help of the following equation:

(7) $$W = \int_v^V P\ dGLOPPE$$

This is, of course, a major simplification. GLOPPE is endothermic also by living on solar radiation and this fact does not allow global warming to be considered the sole result of rendering material structures useless through the metabolic interaction between GLOPPE and the *Surroundings*. GLOPPE augments the greenhouse effect as a result of pollution (extruded heat in material form; i.e., bound energy remaining in the *Sphere*) by lowering the "albedo;" the ratio of solar heat the *Sphere* reradiates into the *Surroundings*.

The *second law* states that the reduction of entropy via creating structures contained in GLOPPE will be exceeded by an increase in the entropy of the *Surroundings*:

(8) $\Delta S\ (\textit{Sphere}) = \Delta S\ (\text{GLOPPE}) + \Delta S\ (\textit{Surroundings}) > 0$

The absolute value of the first (negative) term is smaller than that of the second (positive) one. Note that $\Delta S\ (\text{GLOPPE})$ is the sum of a positive measure, indicating the tendency of any created structure to come apart the second it has been created (the result of thermal agitation everywhere across the universe, including the human brain), and (a larger in absolute value) negative one that stands for the creation of structures, in a temporary defiance of the *second law*.

Fusing various interpretations of the *second law*, it may be said that entropy inescapably and irreversibly increases in the *Sphere* as the matter contained in it drifts toward states of higher probability.

Simple algebraic manipulation of (5) and (8) yields

(9) $-T\ \Delta S\ (\textit{Sphere}) = \Delta H\ (\text{GLOPPE}) - T\ \Delta S\ (\text{GLOPPE})$

The left-hand side of the above equation is defined as change in "Gibbs free energy;" that is:

(10) ΔG (*Sphere*) = ΔH (GLOPPE) ─ T ΔS (GLOPPE)

"Gibbs free energy" is a concise state function that includes those state functions and variables which command interest in the present context. It helps visualize the total, chemically free energy in the *Sphere* because G can be equated with the dot product of two vectors: one containing the quantity of each substance in moles (Γ) and the other the "Gibbs free energy" content of the corresponding mole (M):

(11) $G = \Gamma . M$

Given that ΔH (GLOPPE) is negative and ΔS (GLOPPE) is positive, ΔG (*Sphere*) is negative.

ΔG (*Sphere*) being smaller than zero is the result of the global loss that exceeds in absolute value the sum of billions of dispersed gains ($\Delta G > 0$) which result from the nonspontaneous (endergonic) creation and maintenance of humans and extrasomatic objects.

All this is not intended to prove that GLOPPE is depleting the *Sphere*'s stock of free energy enclosed in structured matter. The contrary would be a sorry exercise in "question begging" because the conclusion reached via enthalpy and "Gibbs free energy" already presumed the hypothesis about the way the *second law* affects the mutually enforced demographic-economic expansion. Growth in the *Sphere*'s entropy was ensured by the continuous negative change in GLOPPE's enthalpy, which in turn, was based on the entropic argument encapsulated by equation (5).

To answer the question "then why not simply state these propositions," no lesser authority than that of Saint Anselm of Canterbury (1033-1109) needs to be invoked: "... unless I first believe," said the father of scholastic philosophy, "I shall not understand." Belief in humanity's thermodynamic reality does not, of course, come from revelation; it is not testimony-grounded wisdom to be imparted through the pastoral leadership of inspired ministry.

The problem of recognizing GLOPPE's entropic nature (as witnessed by the disparagement with which conventional economics defers such recognition) resides not so much in the difficulty of comprehending the basic argument as in a lack of willingness to clear the passage toward its acceptance: Belief in practically infinite resource abundance -- using the conservation law and the bounty of solar radiation as uncritically regurgitated arguments -- is the taproot through which upbeat business psychology, *a priori* confidence in permanently accelerating growth can be sustained in GS2's Keynesian economies.

Under these circumstances, a laconic affirmation that the *second law* bears down on humanity's ecological niche, sagacious as it may be, is next to useless in enlightening the public. It flies in one ear and out the other. Brevity effectively turns the proposition into futile dust by depriving it of its nourishment -- appropriate mindfulness.

When the purpose is to develop an easily blocked-out flash of insight into a firmly held conviction that penetrates the quotidian; breeds theoretical skills and moral capital, grunt work is needed. As demonstrated, even a limited examination of GLOPPE's interaction with its tellurian constraints has hammered home that GLOPPE is a spontaneous process (i.e., it will not stop until the energy potential for its continuation forces it to do so through social means rather than by physically running out of free energy congealed in matter); helped digesting the enormous significance of the qualitative distinction between free and bounded energy, and to think about work, heat, and energy as varied aspects of the same phenomenon.

In the present context, Saint Anselm's sequence relies on the following dialectics: Understanding (which presumes absorption of details) and belief (which hinges on a sound bite) reinforce one another, making both grow until belief becomes strong enough to sustain ecological realism in individual consciousness.

Of course, words by themselves will never substitute for the trauma that separates being stoned on cornucopian ends and principles from entropy-consciousness. But preparatory self-edification by expanding the field, exposing its hidden dimensions, penetrating into its layers through analysis and discussion maybe expected to reduce its length and intensity.

To continue in this spirit, let us sum up in continuous terms, the consequences of GLOPPE's spontaneity. When T is later than t;

(12) $$S\ (\textit{Sphere},\ T) > S\ (\textit{Sphere},\ t)$$

I.e., entropy accumulation in the *Sphere* from t to T (denoted as S*) is positive:

(13) $$S^*\ (\textit{Sphere}) = -\int_t^T S(\mathrm{GLOPPE})\ dt\ + \int_t^T S(\textit{Surroundings})\ dt\ >\ 0$$

The absolute value of the second term exceeds that of the first one, the result of anti-chance (negentropic) structure-forming activities implied by GLOPPE.

Alternatively, using Fermi's equation, (Fermi, 1936, p. 46), the "exchange of heat" between a system and its surroundings will be negative:

(14) $$\sum_i Q_i / T_i\ <\ 0$$

where positive Qs indicate heat (low entropy energy) received by GLOPPE from the *Surroundings* and negative Qs stand for the heat surrendered to them (in the form of higher entropy energy). T_i stands for the Kelvin-scale temperature at which Q_i is

transacted. T_i may also be defined as the average temperature in the area that environmentalists designate as the biosphere. This approach allows for the recognition of global warming, a nonissue until the 1960s, but an exponentially increasing one since then. (Cf. Gore, 2006, 2009, and 2013.)

Current economic fundamentalism, which ignores GLOPPE's diminishing potential to do work (transform heat to work), regards equation (14) as an equality; i.e., $\sum_i Q_i / T_i = 0$; pretending that GLOPPE is a reversible process; and that the *Surroundings* act as a heat bath; i.e., an infinitely large and unchanging thermal reservoir regardless of GLOPPE's scale and dynamism.

The likely slowing of entropy accumulation over equal periods based on (12) is consistent with the famous Boltzmann formula:

(15) $$S = k. \log W$$

where entropy associated with the macrostate of a given system (S) is the multiple of the Boltzmann constant (k) and the natural logarithm of the level of disorder (W) as it is measured combinatorially by the number of microstates conceivable in a given macrostate. Equation (15) suggests that the entropy generation of GLOPPE will necessarily slow down.

This projection is also implied by the general characteristics of the equation showing the time evolution of "Gibbs free energy" in an isolated system. The first derivative of this equation is negative at constant pressure and temperature (conditions that do not interfere with the basic propositions presented in this paper); while the second derivative is positive, implying a decelerating convergence to the minimum. (Cf. Kolesnikov, Vinokurov, and Kolesnikov, 2001, pp. 135 and 136.)

The build-up of entropy may be considered in a different way (following Fermi's "second example;" Fermi, 1936, p. 56): GLOPPE (assumed momentarily to have a fixed scale) "works" on the *Surroundings*, heating them up by friction. Thus, not even "zero population/zero economic growth" would save human civilization from running down its ecological potential. Georgescu-Roegen (1976) made a strong point of this.

The continuous loss of "Gibbs free energy" is consistent with GLOPPE's spontaneous, irreversible (exergonic) nature. Moreover, in conformity with basic thermochemistry, GLOPPE could never use up the entire stock of "Gibbs free energy" theoretically at its disposal. Indeed, there is no conceivable socioeconomic organization under which humanity could extract the last drop of enthalpy from the planet's material structures. Thus, GLOPPE-caused entropy accumulation straining toward the equalization of chemical energy potentials is not expected to eradicate matter in the *Sphere*. As long as the cosmos does not suffer "heat death" -- the cessation of all subatomic vibrations and related chance fluctuations -- this obviously cannot happen. Put differently, GLOPPE

cannot become so big that it would wipe out free energy, turning the *Surroundings* into a homogenously inert (chaotic) system relative to itself.[12]

But this is hardly a solace. GLOPPE can increase randomness in the distribution of terrestrial molecules relative to its biological and economic-technical needs to a point where free-energy containing structures no longer accommodate a large population of well-living individuals. The range of *Homo sapiens*-specific enzymes restricts the pathways of metabolic conversion. We cannot feed on paper or dirt and matter can be used for extrasomatic purposes only as long as the free energy required to access it does not exceed the free energy it contains. Making metal from metal ashes and gasoline from fumes does not promise a brilliant future. And counting on technology to prevent or reverse the general degradation of matter is a defective theoretical orientation. It is equivalent to claiming to have discovered a perpetual motion machine (see 4.3).

Approach to lethally high entropy levels for the species is unlikely to be monotonous. As mentioned before, a smooth approach is conceivable only for nonspontaneous processes. Given, however, that GLOPPE is spontaneous, a major, historical collision (or a series of such collisions) with its constraints looms on the horizon of universal history.

The following assertion lends further support to this hypothesis. Individuals can exist only in an open thermodynamic relationship with their surroundings but socioeconomic institutions and perceived norms of stability tacitly presume that the same openness exists between groupings of individuals (e.g., business firms and nations) and their surroundings; and consequently, between human civilization and the *Sphere* (see 4.2).

In purely abstract terms, events corresponding to a "forcing algebra" (containing a set of forcing equations) will induce GLOPPE to follow a dynamic path of decelerating dissipation. However, for the moment there are no convincing signs that a cure for the emerging disease is developing *in tandem*. The *Drawdown* faces an arduous road on its way of becoming a paradigm. How much effort has been exerted to catalyze the needed enlightenment with negligible results is illustrated by the fact that none of such relatively new concepts as exergy, anergy, ektropy, enstrophy, and emergy (all intended to direct public attention to the world's most basic long-run problem) has won appreciable notice.[13] None of them has acquired *meme* status; that is, "a node in semantic memory" (to adopt Edward O. Wilson's expression; cf. Wilson, 1999, p. 148) with cultural significance.

---

[12] The conclusion of Takuro Uehara's model (Takuro Uehara, 2013) that an "ecological economic threshold" is likely to precede the "ecological threshold" is correct and highly relevant.

[13] The term exergy is attributed to Zoran Rant (1904-1972). It combines the energy and entropy balances of a closed or isolated system; i.e., its distance from thermodynamic equilibrium; or equivalently, the maximum work it is capable of performing. Anergy is its complement. Thus, Energy = Exergy + Anergy. Exergy has been used in several publications. (See, for example, Diederen, 2010.) Ektropy is the negentropy living structures need (cf. Georgescu-Roegen, 1971, pp.190 and 204). Enstrophy refers to energy decay (dissipation). It comes from fluid dynamics. Emergy denotes the amount of exergy deployed in realizing qualitative transformations. (H. T. Odum used this concept in his pioneering work on integrative environmental accounting; cf. Hall, 1995.)

***

To conclude this section, let us underscore that GLOPPE's engagement of the *Surroundings* cannot be viewed as a purely physical phenomenon; i.e., a process of equalization that targets mechanical, thermal, and chemical nonuniformities between two compartments of an isolated system. Movement toward thermodynamic equilibrium (maximum entropy) proceeds through what, from Nature's perspective, appears to be the anti-entropic effort of life. Indeed, GLOPPE's existence and dynamism reveal the six characteristics of living systems:

(i) The human biomass (without which its extrasomatic extensions would obviously not exist) is composed of cells; (ii) GLOPPE is an organization (in the age of global systems) that turns simple substances into complex ones while maintaining internal equilibrium (homeostasis); (iii) it uses energy to survive; (iv) it grows; (v) it reproduces (also in the extended sense of maintaining institutions as well as matching behavior-conditioning legal, cultural, ethical fixtures required for stability in inter-subjective relations); and (vi) it responds to the environment (including its self-created socioeconomic environment) in adaptive ways as it grows and its relationship with the *Surroundings* changes.

4. Grand illusions of anthropocentrism

Considering the *Sphere* an isolated instead of a closed thermodynamic system and GLOPPE a spontaneous rather than a nonspontaneous process has powerful implications for the future. Whereas a nonspontaneous process in a closed system decelerates as it approaches equilibrium; this is not the case for a spontaneous process in an isolated system (Kolesnikov, Vinokurov, and Kolesnikov, 2001, p.135). That is, GLOPPE is programmed to collide with its constraints.

With a naiveté that will be the wonder of later generations, contemporary, thermodynamically ingénue economics celebrates the small fractions that energy and material resources represent in the national accounts of advanced countries.[14] It flatly ignores that the increasing volumes of free energy, which stand behind the relatively small percentages, are irreversibly growing subtractions from a fixed stock. Science, in general and in the long run, cannot reverse this process because its economically feasible applications through technology are a function of the average condition of matter in the *Sphere*.

Neoclassical market fundamentalists prefer to dispense with the *second law* by making false references to the *first law*[15] and by calling the *Sphere* a thermodynamically open

[14] Given the total inelasticity of demand for energy and material resources (and the unrealistic expectation that science and technology will always find equally low price substitutes within the mass of material that enters the economic process) price increases are matched by increases in spending shares. Once the price rises significantly for a key resource (e.g. oil), the dynamics of aggregate demand spells danger for economic expansion, eliminating incentives for substitution.

[15] "Assuming a small and exhaustible supply of resources is nonsense. This defies the law of conservation of mass-energy and denies the fact that in the earth's crust beneath the sea and further toward the core there

system because of abundant solar radiation. Let us start with the second way and deal with the abuse of the *first law* under point 4.3 *et passim*.

4.1 Worshipping the Sun God

Economists wax eloquent about the sun reflexively to protect their beliefs from that darn red herring of entropy: "It is appropriate to conclude that, as long as the sun shines brightly on our fair planet, the appropriate estimate for the drag from increasing entropy is zero" (Nordhouse, 1992, p. 34).

The quoted work is certainly *la pièce de résistance* in tarring the applicability of the entropy principle in economics with a neoclassical brush. Observe the double sleight of hand when Nordhouse quotes Georgescu-Roegen's statement: "the entire stock of natural resources is not worth more than a few days of sunlight" (Nordhaus, 1992, p. 34). By mistakenly claiming that Georgescu-Roegen considered solar radiation "negentropy income," Nordhouse made Georgescu-Roegen negate his own thesis.

Georgescu-Roegen referred to negentropy as a concept of dubious value that somehow managed to become current in denoting information as the exact opposite to disorder (a "throwing the baby out with the bath water" kind of overly sweeping criticism on his part with which the present author respectfully disagrees). But by characterizing solar radiation as negentropy, a lot can be gained to make the world safe for eternal economic expansion. Namely, negentropy so used brings solar radiation and material resources under a common aegis, implying substitutability between its two subcategories. Two factors help maintain this illusion: First, both solar energy and free energy enclosed in material structures can be expressed in calories (or in some other measure of energy); second, there is a theoretic equivalence between energy and matter since Einstein discovered a fixed exchange rate between the two; i.e., the speed of light squared. It is a huge number, but a constant one. Matter is energy and energy is matter. But we need to think a little further!

The substitutability between solar radiation and matter is one way: We cannot make matter out of energy. Despite their theoretical equivalence; matter and energy have an important asymmetry. There is no technology to produce economically significant quantities of matter from energy.

It is the relatively high concentration of energy compared to the ambient environment that renders an energy carrier precious. Calories that the sun pours on the Earth are diluted compared to the concentration of free energy contained in fossil fuels (Diederen, 2010, p. 28). All forms of (fund-service type) solar energy need free energy contained in material structures to be harvested. Thus, ultimately it is the internal energy (the sum of kinetic and potential energy) contained in the fixed number of terrestrial corpuscles that limits GLOPPE. The much-heard bleating about the long-term tendency of natural resource prices to decline originates in an optical illusion that sees the pastures of the

---

are vast supplies of mineral resources, some located and charted and others known to exist in a general way." (Lipsey and Steiner, 1975, p. 860.)

future as a mirror image of the past. Natural resource prices do not reflect entropic reality simply because economic thinking is oblivious of a deeply ingrained fallacy of composition.

4.2. Believing that openness of the parts is also a property of the whole.

All carriers of life exist in open thermodynamic systems as energy and matter flow in and out through their boundaries. Nourishing low entropy (ordered structures) enters the individual and after being used for growth and/or maintenance, it is extruded into the environment as higher entropy (more disordered) structures and body heat. The local reduction of entropy (manifest in anabolism), with its inevitable consequence of increasing entropy in its surroundings (through catabolism), appears as the right-to-life steady state for the individual; in fact, so much so that the organism's thermodynamic openness (henceforth *openness*) has been extended to group behavior.

The question "What will it take for global society to recognize that inconsiderate and contentious *openness* is the most obtrusive adversary of a dignified, commonly shared future?" cannot be answered. Yet even a cursory glance at universal history encourages the requisite induction.

Resource issues caused the exodus from Africa during the waning ten thousand years of the Middle Paleolithic and, much later, from Asia during the Upper Paleolithic and Mesolithic periods. Europe was colonized (displacing the Neanderthals); Paleo-Indians migrated from Central Asia to the Americas; and, radiating along the south-east coast of Asia, human genes reached Australia.

Nomadic groups migrated when their expanding ranks depleted the area where they sustained themselves through hunting, fishing, and gathering or when demand for the same resources by rival groups pushed them toward new horizons. Later, when animal husbandry was added to the roaster of economic activities, the exhaustion of (or competition for) grazing soil added to the push.

Problems with extrusion of high entropy (henceforth *extrusion*) must have been insignificant relative to finding food and shelter. In due time, the pressure exerted by rendering the intake of low entropy (henceforth *intake*) sparse, along with the psychological strain caused by permanent commotion, insecurity, danger, and occasional starvation inspired efforts to use land more intensively. The Neolithic Revolution (beginning ca. 10,000 BCE) marked the dawn of agriculture and the creation of fixed settlements on each continent.

Leaning heavily on livestock production (primarily sheep and cattle farming), tillage-by-hoe agriculture was extensive. Military conquest compensated for the decline in crop yields and for the wholesale generation of fallow land. But intensification through crop rotation, irrigation, the use of fertilizers, and ever more advanced tools did not bring world peace. Population growth outstripped productivity growth, catalyzing the motivation to build empires.

As a by-product of early urbanization (in the Nile Valley, the Fertile Crescent, and later in China) the problem of *extrusion* appeared in the form of epidemics, caused by fecal contamination and the consumption of infected animal meat. Spontaneously developing transitional zones between adjacent communities (so-called ecotones) became common sources of infection and primitive, high-density settlements were hotbeds for host-to-host transmissions. Medical history has demonstrated the presence of bubonic plague, smallpox, typhus, and tuberculosis long before the Christian era.[16]

Industrialization had set into motion humanity's rapacious quest for *openness*. This historic process began most markedly in China at the outset of the second millennium (CE); and, after establishing footholds during the late medieval period in Western Europe (with the British Isles in the lead), it embarked on its ever more pronounced acceleration after 1500 -- the symbolic year that marks the attainment of geological globalization. The *intake* was unbridled and brutally competitive at every level. Nations grabbed as much land as they could through conquest and colonization; the accumulation of extrasomatic structures as personal property and in the ownership of production units assumed the norm of rational conduct. The road for the democratization of this overwhelming objective became ever wider and unobstructed as the bourgeoisie struggled with increasing success for the creation of markets in labor, commodities, and money.

The conflict between unconstrained *extrusion* and GLOPPE's growth exploded during the 14th century with the bubonic plague ("Black Death"). While the expanding urban centers of Asia and Europe lacked the most elementary infrastructures and measures of public sanitation, the intensification of commerce between the continents guaranteed the spread and lack of effective control of *Yersinia pestis* (the bacterium generally held responsible for the devastation).

The learning process had been halting and painful. Even after the danger of total extinction subsided, bubonic plague returned in later centuries along with smallpox, cholera, typhus, and influenza.[17] It took many generations to recognize that larger volumes and more varied masses of waste widen the ecological niche for rodents, fleas, lice, and bacteria, multiplying the fecal-oral pathways of infection.

En gros, epidemics may be considered a symptom of inadequate adjustment in *openness* to changed conditions in a community's relationship to its environment. Population growth increases *intake* and *extrusion*; and higher density, in the context of intensified geographic connectedness, demands new communal equipment (e.g., sewers), hygienic

[16] Cf. Despommier, D., Ellis, B.R., and Wilcox, B.A., "The Role of Ecotones in Emerging Infectious Diseases:"

http://www.hawaii.edu/publichealth/ecohealth/si/course-ecohealth/readings/Despommier_etal-2006.pdf

[17] For a list of major epidemics through history, see the following site:

http://en.wikipedia.org/wiki/List_of_epidemics

standards (e.g., rules regarding food and water safety), and practices (e.g., burial protocols and waste disposal) coupled with matching stringency in individual self-care and inter-personal relations. The evident difficulty of such evolutionary adaptation lies in the complexity of going from one structure of *openness* to the next, where the word "structure" intends to convey the mutual interdependence of technical, social, and individual factors. In retrospect, society's adaptation to the conditions its expanding ranks and productive activities have created appears as a victory of human *vis viva*. But the ultimate accomplishment is not at hand. The age of global systems has not given birth to the recognition that the materialized aggregate of human aspirations (GLOPPE), conceived through the actualization of ever greater measures of *openness*, is filling up a thermodynamic system that is not open.

GS1 did register significant success in preventing and containing epidemics but it may be better characterized as providing the socioeconomic fabric for a ruthless pursuit of *openness* at all (i.e., individual, business firm, and national) levels. The roaring burst of demographic and economic growth during the system's most successful, Victorian-Edwardian period stifled early clarion calls about resource depletion and environmental degradation.

GS2 has brought a major but not a critical change. Since the late 1950s preoccupation with conservation and environmental protection has become a permanent and often passionate dimension of social discourse. But despite all laudable efforts, respectable partial results in policies and technical fixes, the typical consciousness cannot reconcile the world's growth dependency on its material welfare (i.e., individual income derived from economic activities) and the ever worsening disequilibrium between GLOPPE and its physical possibilities. If it could, then GLOPPE would not be a spontaneous thermodynamic phenomenon and reason could guide it to a smooth landing.

Regarding *intake*, most of the planet's inhabitants continue to welter in the illusion that material abundance can grow forever. They could not care less about the unsustainable resource demands their actual level of living generates or what their aspired level would entail. Firms are even less sensitive and for a good reason. Private business cannot survive without expansion (a basic fact that zero-growth advocates tend to overlook) and expansion means more material and energy. Jubilation over the historically recent structural evolution of highly developed economies -- the coming to dominance of the service sector and specialization in relatively low-natural-resource-dependent high-tech products -- is an astonishing example of narrow minded rationality.

There is no ameliorative slowing in the *Drawdown* when a nation imports material and energy-intensive manufactured goods from China instead of producing them domestically! Moreover, only one-fifth of the planet's population possesses the fixed assets necessary for a civilized life (as the concept is interpreted today); and even in the implied ensemble of the developed countries, infrastructures need to be replaced from time to time. The idea that GLOPPE's *Drawdown* can assume a viably slow pace through an agreement reached among the three blocks; the developing world (defined by the *The World Bank* as "Lower Middle income economies" and "Low income economies");

emerging economies, and the richest nations, is about as realistic as "Goldilocks and the Three Bears."

Confrontation-laden Post-Cold War[18] geopolitics has revolved around access to natural resources, oil chief among them. An extensive study (commissioned by the Swiss National Science Foundation) at Columbia University[19]confirmed that asymmetry in resource endowments has been a *casus belli* in international relations since the end of World War II. The study has also revealed that the closeness of oil fields to a sovereign state's administrative borders tends to invite strong-arm showdowns.

On the *extrusion* side, the GS2 era has ushered in many admirable public initiatives and welcome adjustments in individual thinking and behavior. But here again environmental concerns are trumped by the dependency of general welfare on the expansion-demanding profitability of economic activities.

Most firms acted as uninhibited, devil-may-care polluters as long as they could. The pulp and paper industry had to be told that its activities caused deforestation and pollution. The designation "smokestack industry" (e.g., iron and steel works and the chemical industry) came into vogue during the 60s. Toward the end of the last century, public pressure in industrialized democracies had finally resulted in fairly comprehensive regulations both upstream (e.g., via "dirty input limits") and downstream (e.g., "emission controls"); that is, at both the in-taking aperture and the extruding cloaca of man's extrasomatic (industrial) "digestion." Certainly, but then large businesses began to pass on environmental harm to poorer countries.

Data on international waste trade shows that residues of production and consumption, too dangerous or uneconomical to recycle (either because of their quality, composition, material nature, or lack of demand) tend to end up in the world's poorer regions. Shipments of refuse from the rich to less-well-to-do countries increased markedly since the 1980s as governments in the former category imposed restrictions and higher costs on domestic waste disposal (cf. Tiemann, 1998). An especially sharp increase has been noted in transporting "dead electronics" (so-called "e-waste") to developing nations. The 1989 "Basel Convention for Controlling Transboundary Movements of Hazardous Wastes and their Disposal" attempted to impose "global environmental justice," but not surprisingly, entrepreneurial interests have been finding ways to play out these good intentions (cf. Clapp, 2001). Similar concerns plague the long-term disposal of high-level (non-recyclable) radioactive waste. While governments in the developed world struggle

[18] The four decades of world-conflagration-threatening standoff (known as the Cold War) was about global systems. Communists, led by the Soviet Union, wanted to replace GS2 with their own system. (See Pogany, 2006).

[19] Caselli, F., Morelli, M., and Rohner, D.; "The Geography of Inter-State Resource Wars:"

http://econ.columbia.edu/files/econ/camoro_2013_4.pdf

for the public acceptance of "deep-mined geologic depositories" within their respective borders, Central Asia is on the way to become the world's radioactive waste dump.[20]

Whereas in the past, disequilibrium between *extrusion* and the world's self-organization was manifest primarily in the person-to-person transmission of epidemics, the range of postwar environmental problems has become incomparably wider. Leaning on well-founded scientific evidence and forward thinking, the environmental agenda now includes heightened concerns about global warming and pollution. The first one is tied to extreme weather, malnutrition as a result of droughts, and an increase in the frequency of natural disasters. Air, soil, and water pollution is expected to multiply the potential of vector-borne diseases (e.g., malaria) and threaten the individual's breathing and digestive systems. It could be held responsible for birth defects and it may even prompt harmful mutations in the human gene pool.

Wallowing in *openness* has indeed become a menace to *Homo sapiens*/*Homo faber*. William Rees' "ecological footprint" analysis (see, for example, Rees, 2006) is an excellent start to examine this universal phenomenon numerically.

"Ecological footprint" converts into a synthetic surface measure ("global hectare") the resources that a certain level of living and associated life-style commands. Calculations allow for comparisons among nations; even among individuals. If the results, pointing to a serious "ecological deficit"[21] for the world as a whole, were not alarming enough, the actual situation is far worse. Simultaneously -- and as a clear consequence of -- the prolonged ecological overshoot, the planet's capacity to supply renewable resources on a sustainable basis is declining. What is more; the whole exercise ignores nonrenewable resources; thus, the unavoidable depletion of structure-borne free energy; the qualitative (thermodynamic) degradation of the *Sphere* in accordance with the *second law*.

Even with these limitations, "ecological footprint" analysis shows worsening ecological conditions; and differences among nations are becoming more accentuated. Judging from GDP growth forecasts, fast-developing economic giants, China and India, are slated to increase their "footprints" dramatically, playing catch-up with the ecological intensity of developed economies.[22] By and large, developed and fast-developing nations will

---

[20] See, for example, Biggar, H., "Radioactive Waste Threatens Central Asia," published in the *Europe and Central Asia Newsletter* of the United Nation Development Programme:

http://europeandcis.undp.org/news/show/3162BB7C-F203-1EE9-BF11E0BCB6B5DBA4.

[21] Fifty percent is perhaps the most frequently quoted number, meaning that it takes one and a half years to regenerate one-year's worth of the renewable resource bundle demanded by the human biomass.

[22] Dietz, T., Rosa, E.A., and York, R. introduce a technique for projecting future levels of ecological footprint and make some interesting international comparisons:

http://faculty.washington.edu/timbillo/Readings%20and%20documents/SUGGESTED%20READINGS/dietz_etal_2007.pdf

escalate their *openness* more blatantly than the rest of the world. If one also takes into account increasing income inequalities within countries (as noted, for example, by Gore, 2013) as an indicator of widening footprint differences within national communities, it becomes apparent that the world is oblivious of its thermodynamic fallacy of composition.

The sober conclusion is that thinking about *openness* has not changed all that much. It is still true that *Homo homini lupus* when it comes to claiming low entropy and vindicating the right to dispose freely of the feast's useless and harmful remnants.[23]

4.3. Falling for the perpetual motion fallacy.

Nonecological economics imputes a prohibitive marginal cost to restricting the transfer of free energy from the *Surroundings*. Its fundamental message is that growth is equilibrium and equilibrium is growth. So had it been in the past, so it is now and so it shall be in the future.[24]

"AK" models, the most primitive form of endogenous growth theory, lock out diminishing returns. By enlarging the concept of capital to include human capital, this feat could be accomplished even without technical progress. More advanced elaborations (e.g., "innovation-based growth theory") appeal to technological advancement, superseding Robert Solow's "manna from heaven" no-explanation needed explanation of technical progress (cf. Solow, 1957). But it does not take much to discover that technical progress (production technology, increase in the number and quality of products), as par for the course of endless endogenous growth, still remains a kind of never-ending supply of gold nuggets. True, they don't fall from heaven. They are handed out by the Invisible Hand of Maxwell's Demon.

With incisive clarity, Romer (1990) defined technical progress (the inexhaustible driving force of economic growth) as "improvement in the instructions for mixing together raw materials." We can recognize Maxwell's Demon despite the Adam Smith wig tied in a bag with ribbons that he now wears.

To remind the reader, Maxwell's poignant thought experiment featured a Demon who miraculously flouts the *second law* by operating a trap door that separates a relatively energy-rich and a relatively energy-poor compartment within an isolated system. Using his magic wand, he opens the door only for high-energy molecules from the low-energy compartment and for low-energy molecules from the high-energy compartment. Instead

[23] A detailed survey of households in the Netherlands showed a low level of "energy literacy and awareness" in the population (Brounen, Kok, and Quigley, 2013). Based on the questions asked in the survey and on the country's high living standards (coupled with its significant ecological footprint), one may justly conclude that, on the average, even relatively wealthy individuals remain unconcerned about the planet's growing resource problems. The contrarian view, expressed through the Environmental Kuznets Curve (EKC), is GS2 ideology under an analytical carapace. (Wagner, 2008, compellingly criticizes the econometric methodology deployed in support of EKC.)

[24] For an authoritative and comprehensive survey of growth theories, see Barro and Sala-i-Martin (1995).

of evening out energy levels (as Nature has taught man invariably happens), the "rich become richer and the poor become poorer."

Traditional economics makes an analogous claim. Relying on his growing stock of information, the Demon directs high energy from the *Surroundings* into GLOPPE and it releases ashes and fumes; low-energy content particles or bound energy (economically inaccessible heat) into the former, without increasing overall entropy in the *Sphere*. This demonic *legerdemain* falters on the information-entropy tradeoff: Increase of information at the Demon's disposal is a reduction in entropy only within a sharply delineated part of the system (the sum of the two variables is always zero within its bounds). We cannot outfox the *second law*. Increase in the entropy of the entire system (i.e., in the *Sphere*) must exceed the reduction of entropy (by way of more technological-scientific knowledge being translated into goods) within any part of the system (i.e., in GLOPPE).[25] Information is not free. It has an entropy cost imposed on the whole of the isolated system. The Demon pretends to be ethereal when we observe him but he wolfs down pizza off stage.

Endogenous growth theory makes it clear that technical knowledge (information containing instructions on how to work with raw materials) is inherently different from other economic goods, most importantly because such instructions can be used over and over again. This conceptual separation helps to see the parallel between endogenous growth theory's notion of technical development and Maxwell's Demon.[26]

Economics coldly asserts that there is no free lunch: "positive" production is nonsense without inputs; e.g., $(Y_j \cap R^r{}_{++} = \varnothing$; Ginnsburgh and Keyzer, 1997, p. 39). Then, with abstractions so remote from real life that they would make the Sage of Königsberg shake his head, transformation functions focus on constrained maximization. The magic occurs through the illusion created around the constraints: GLOPPE prestidigitates them away as it grows.

To safeguard the holy grail of eternal acceleration, traditional economics flashes its deputy's badge already at the city limits. A not overly derisive way of sending the entropy principle back to where it came from (i.e., to Georgescu-Roegen) entails the trump argument that comes so naturally to quantity-obsessed rational consciousness: whatever cannot be subjected to mensuration is irrational. Or, equivalently, if there is such a thing as entropy accumulation at all, market prices already reflect it because they reflect everything.[27] (See point 6. for an explanation on how a-historic objectification of market prices blindfolds analysis.)

---

[25] For an accessible and entertaining description of the information-entropy liaison, see Chapter One in Loewenstein, 1999.

[26] Endogenous growth models distinguish among physical, human, and intellectual capital. The first grows as a result of savings, the second via education, and the third through monopoly-rent-motivated R&D (with public support here and there).

[27] Nordhouse, for example, puts "negentropy drawdown" on the back of the venerable neoclassical production function workhorse by way of a clean-as-a-whistle dynamic term, and then he takes it off stating that prices already reflect it (Nordhouse, 1992, p. 33).

Although wholly unidentified, the Economic-Entrepreneurial Demon who pushes out GLOPPE's growth possibility frontier (as if there were no second half of the 21st century) is alive and well in the dogmatic certainty of present day economics. In a "min"-prefaced aggregate production function that combines labor, land, capital, natural resources, and technology, this last term includes an endogenous process that assures natural resources will never be the narrow constraint. This is more than just free lunch. It is free meals forever and anon.

The Demon resembles manna from heaven for bored patent clerks who can hardly wait for the next "perpetual motion machine" inventor to send the office into roars of laughter (once the crank is safely out of the building).

The secure horizon of endless growth already hints that the economy is a *Perpetuum Mobile*, running on the virtually infinite duration of sunshine. But, of course, it has a more respectable name: It is called "market-incentive-driven, technology-facilitated unceasing growth guaranteed by eternal, seamless substitution."

In more detail, *Perpetuum Mobile of the Fist Kind* (the one that violates the *first law*) assumes that one can get out more energy from a process than one puts into it; or, equivalently, that work can be done from bootlegged surplus energy. The concept of endogenous growth does something like that. From the alchemy of competitive search for monopoly rents coupled with institutional assurances to diffuse knowledge, it secretes technology-generating ideas; quanta of motive power that are additional to energy (including material) inputs accounted for by economic data.

But endogenous growth is more ingenuous than your usual "something for nothing" contrivance. It has also discovered a *Perpetuum Mobile of the Second Kind* (the one that violates the *second law*): GLOPPE expands without dissipation. It is implying even a *Perpetuum Mobile of the Third Kind.*[28] This magnificent dream assumes a mechanism so free of friction and heat loss that it becomes one hundred percent efficient; i.e., GLOPPE of any scale can run indefinitely on the *Sphere*'s limited material resources.

4.4. The party of techno-drunkenness continues.

Rejection of the *second law* is rooted in mankind's nostalgia for timelessness; or, if that cannot be granted, at least for the continual increase in comfort and convenience as compensation. This entrenched impulse is as understandable as wishing for permanent blue skies.

4.4.1. C2C

The exaggerated optimism reflected by the "Cradle to Cradle" principle, which began with the publication of Braungart and McDonough (2002) comes dangerously close to implying that human-built mechanisms may be perfected to a point where they imitate Nature's eternal self-equilibration in the broadest sense. Many suggestions that arose

[28] Not related to the third law of thermodynamics.

from the C2C movement are, of course, commendable from the environmental and conservation standpoints but its cornerstone is not less quixotic than a perpetual motion contraption. It lives on the false premise that the old cliché "Nature is always in equilibrium" can be made net of matter's qualitative degradation.

.

4.4.2. Giga-gushing about "nanotech"

The fast expansion of nanotechnologies, including spin-transport electronics ("sprintronics"), is doubtlessly a significant development with potentially vast effects on the future. But a fair warning is in order. Nano-engineered materials used in various devices, in coatings, cosmetics, and golf balls have not kicked the depletion of nonrenewable resources off the field of human concerns; i.e., the *perpetuum mobile* is not at hand. Since scanning and funneling at the atomic level is frightfully evocative of Maxwell's Demon, it is so much more important to remember Maxwell's rejection of the possibility of violating the entropy law, along with other cogent arguments that disprove the latent existence of the Demon.[29]

Sober preliminary assessments underscore that the spread of nanotechnology will demand vast amounts of energy, water and various polluting chemicals. The impact on the global environment will remain unknown for decades but is presumed to be negative.[30]

To put the new technique in perspective, let us not lose sight of at least three general, unchangeable conditions of the world we live in: (i) nanotechnology will not reduce overall human need for structured matter. Regardless of how a product is manufactured, it must remain at the human scale to have use value. (Ceramics may be produced through manipulating molecules but who wants a Procrustean loo?); (ii) to the extent material is saved via an actual increase in productive efficiency, the economic system's growth dependence will claim the savings (Jevon's paradox!); (iii) regardless of how production technology evolves, the associated reconstitution of matter will not change the *Sphere*'s inventory of atoms. It will only push it toward a greater disorder; reducing humanly comprehensible information about where they are and what they are up to.

---

[29] Cf. Norbert Wiener's frequently quoted argument (Wiener, 1961, p. 58).

[30] See, for example, the study of the *International POPs Elimination Network's Nanotechnology Working Group*:

http://nano.gov/sites/default/files/dsti_stp_nano201212.pdf

To appreciate how little governments know about the extent of use and impact of nanotechnologies, consult the report of *OECD's Directorate for Science, Technology and Industry, Committee for Scientific and Technological Policy, Working Party on Nanotechnology*:

http://www.eeb.org/documents/090713-OECD-environmental-Brief.pdf

4.4.3. Ode to algae, 1D- thinking about 3D-printers

The perpetual motion phantasm lingers also around algal (cellular) oil. It seems inexhaustible indeed if it is tied mentally to solar radiation alone, abstracting away from its nonrenewable material/environmental costs. The pioneering multidisciplinary approach involved in its development merits heartfelt congratulations. But let us remember what financial huckstering around this great promise wants investors to forget: Commercial-scale motoring on the "green muck" is at least one generation away. And it is impossible to tell what the relative significance of this form of bio-energy will be once the tipping point in the transition toward a global renewable energy base is reached.

The wide-eyed hubris about 3D printers; the creation of self-multiplying machines that will put production on an automatic pilot, as it were, lends acute topicality to Goethe's cautionary tale about the Sorcerer's Apprentice. Besides its physical impossibility, an autonomous global machine (a single, aggregate use-object) that would produce everything humanity ever needed and wanted would obviate Labor and Capital, and free enterprise (as we know them), along with economics, pretty much as Rosa Luxemburg envisioned the end of this field of inquiry through central planning.

5. The thermodynamic view of universal history

GLOPPE is what physicists call a "far-from-equilibrium, dissipative structure" (FFEDS) that evolves unidirectionally, irreversibly and has emergent properties.[31] Ilya Prigonine, Nobel Laureate chemist (1917- 2003), is credited for establishing this school of thought.[32] The time evolution of a FFEDS is marked by relative steady states separated by chaotic transitions (or bifurcations).[33] Evolutionary theories also characterize this pulsatile sequence as order/disorder, equilibrium/coordination disequilibrium; discontinuous transformation, "evolution by jerks" (as opposed to "evolution by creeps"), and punctuated equilibrium.

Descriptive world history traces the thermodynamically-rooted process: Three centuries of GLOPPE's steady growth preceded the Industrial Revolution during the second half of the 18th century (with Great Britain as its center) and the social revolution that began in France with the storming of the Bastille in 1789. A *chaotic transition* that subsided only in the 1830s led to the genesis of the first global system, GS1, characterized as *laissez faire/zero multilateralism/metal money*. GS1 fell apart with the outbreak of World War I. A new *chaotic transition* that lasted until the end of World War II ushered in the second and current global system; *mixed economy/weak multilateralism/fractional reserve money.*

[31] "Far-from-equilibrium" refers to systems/structures that are separated by a considerable distance from "equilibrium," which, for the physicist, means the homogenous dispersion of matter.
[32] Prigogine (1997) provides an overview; Pogany (2006) describes the theory's application to history.
[33] Rosser (1991) surveys the use of "chaos" and the closely related concept of bifurcation in economic literature.

One is not mistaken by designating the first global system as "classical" and the second one as "reformed" capitalism. There are significant differences between the two. Whereas Capital enjoyed nearly absolute power over Labor under GS1, GS2 is based on a compromise between the two. Labor can bargain collectively, workers enjoy unconditional legal and political enfranchisement in industrial democracies (GS2's *vanguard*); respect and dignity in all spheres of life. From being a mere watchman of private property under GS1, the role of the state has increased to that of a responsible director of economic and social development. The international community had no framework of cooperation under GS1. As of the second half of the 20th century, it has the United Nations with its many charter organizations.[34]

Social science does recognize the difference between classical and reformed capitalism but only with a shoulder-shrugging indifference. It misses the significance of this historic transformation; namely, that it is the result of an ardent struggle; that it is irreversible, and that it is the human face of a physical (thermodynamic) process.[35]

Each global system has its *text*.[36]

The basic operating principles of a unified world economy, as elaborated in David Hume's price-specie flow (1752) and Adam Smith's *The Wealth of Nations* (1776), may be considered GS1's *text*. GS2's *text* is the introductory economics college textbook, the prototype of which, authored by Nobel Laureate Paul A. Samuelson (1915-2009), first saw the light in 1948.[37] To use a religious metaphor, the "General Theory" (Keynes, 1965), published in 1936, was the synoptic gospel, based on which Samuelson penned both the Roman catechism, the "Foundations" (Samuelson, 1948), containing the cornerstones of faith for dedicated men of the cloth; and the Baltimore catechism ("Economics") for use in classrooms around the world. The latter work has served as the boiler plate for numerous other primary tools of university-level economic education as well as the canonical source for "penny catechisms" (the simplified and brief "Q and A"

[34] This theory is described in more detail in Pogany (2006 and 2012) and in:

http://mpra.ub.uni-muenchen.de/27221/1/MPRA_paper_27221.pdf

The Appendix of the cited working paper, entitled "Synopsis of world history as the narrative version of thermodynamic unfolding" accounts for the role of communism in tuning GS2's institutional parameters.

[35] For the sake of illustration, let us compare GS1 to the *Matrix* in the like-titled motion picture, and GS2 to *Matrix Reloaded*. Of course, the analog has its limitations. Most importantly, whereas the cineastes' conceptualization suggested extra-terrestrial domination over life on Earth, the proposed theory maintains that the control is exerted by antropogenic abstractions that became embodied in institutions and guidelines for adaptive behavior. The control exerted by a global system is certainly extra-individual. Moreover, given that the history of global self-organization is enveloped in (or is the manifestation of) a dissipative thermodynamic process, it may also be considered extra-human, thus validating artistic insight to a large extent.

[36] Cf. Pogany (2012).

[37] Ibid.

approach) to enlighten the general public as to why common sense leads to GS2 and why it radiates the glory of salvation.[38]

GS2's *text* implicitly considers growth limitless. Citing the secular rise of real wages during the industrial age, technical progress offsetting the law of diminishing returns in the aggregate and over the long run; the small percentage that land and material inputs represent in total output, it dismisses classical predictions about global output running out of steam.

The second half of the 20th century was the time to celebrate the analytical apparatus of GS2's *text*. *La crème de la crème* was decorated with prizes in the memory of Alfred Nobel and the rest of the tiers followed obediently.

But now, well into the first half of the 21st century, the world has to deal with the consequences of the species' frenetic demographic and economic expansion. With a population over seven billion and an annual economic output pushing toward the $90 trillion mark (on a PPP basis), the old system no longer works and no emetic in the form of policies, programs, or reforms can purge it of its outdated principles and parameters. A new social contract is needed, one that takes into account the relationship between the planet's occupancy and its physical constraints.

Yet the GS2-typical mind's belief in the eternity of the extant form of national and global economic organization remains unshaken. Awakening to ecological reality remains lackadaisical and fragmentary. The *text* goes on living as if it were business as usual: Thanks to man's entrepreneurial and technical genius; the infallibility of the price system, combined perhaps with some limited public guidance, all existing and potential environmental and resource problems are as good as solved. Growth can go on forever. It is equilibrium, after all!

No one can be blamed for this. The *text* cannot adapt in major ways because it is an organic constituent of the firm alignment among all levels of organization (from the local to the global), incentives, exhortations, coercions, and expectations. The relentless augmentation of output is the bedrock of profit-maximization through decentralized business decisions, the core principle of both GS1 and GS2. Competition as the main driving force under both systems implies capital accumulation because of the simple fact that cost reduction is its main method; and because its workings are inextricably linked to the endogenous reciprocity between the surging human soma and the accumulation of produced extrasomatic low entropy.[39] Economic expansion that occurs roughly at the clip

[38] The suggested doctrinal parallel connects GS1 with the *Old Testament*. However, given the state of communication technology during the first global system's lifetime, the prophetic insights of Hume and Smith never made it into a *text* comparable to Samuelson's "Economics." One may venture to say that "General Theory" (Keynes, 1965) provided the first historically valid assessment of GS1's organizational foundations.

[39] Satisfaction of a ceaselessly increasing demand for capital goods through private markets is linked to the growth of manpower, the availability of wage goods, and the private-debt based money supply, which must grow faster than debt is extinguished; otherwise economic growth slows and stops. The integrality of GS2's spontaneously coordinated demographic, economic, financial, and monetary processes reveals the system's

of the real rate of return (sum of population and productivity growth) remains a central orientation point for economists. Nonetheless, trying to apply the *text* to never-before-seen phenomena, traditional thought faces growing criticism from outside the mainstream.[40] Reality's much more severe judgment cannot be far.

The *text* hides the impossibility of interminable acceleration by making annual GDP growth appear like walking on a flat plateau of ordinary socio-political-economic existence. Of course, the "business as postwar usual" 3-4 percent *per annum* global growth till mid-century would mean a doubling of the world economy every 25 or 18 years, respectively.[41]Rising energy and material input prices at full employment (or appreciable movement toward it), in association with the increased fragility of the world's tangled and twisted monetary-financial system; and ever more likely environmental calamities, guarantee a totally different horizon.

The bottom-line: Long-term planetary sustainability cannot be carved out from GS2's wood. Global self-organization will have to be restructured. A new world order (GS3) is needed. It may be characterized as *two-level economy/strong multilateralism/mostly government money* (*maximum reserve banking*).

Legally binding international agreements on the use of nonrenewable energy and material resources, as well as on harmful emissions, would enlarge the government's role in economic affairs since administrative methods would be needed to ensure national compliance with globally-determined goals. The implied "strong multilateralism" would split national economies (hence, the world economy) into a free-market and a public authority-dominated sector. While carrying on the best traditions of constructive entrepreneurship, businesses in the first domain would bid for resources and emission rights; joint private-public ownership would prevail in the second one. The state's substantial holding of private shares would eliminate most, if not all, income taxation. The monetary system would be based on a global currency, issued by the global central bank. The ability of private banks to create money through lending would be kept to a minimum. The economic role of grass roots communities would increase significantly.

This brave new world is clearly out of reach. It is, in fact, literally repulsive! Who wants governments getting so deeply involved in economic management; who wants a global currency and a global central bank? No one! -- Except perhaps the *Illuminati* and some groups wielding enormous economic power, according to the conspiratorial fringes of the Internet. No, no, and no again! In light of the eventual need for a system that does not collapse without acceleration, the only possible answer to the question "What will it take

---

Achilles' heel -- accelerate or collapse! It is worth noting that even centrally planned, "nonmarket" economies would decelerate if they attempted "simple reproduction." Marx already saw this. (Cf. Luxemburg, 1968, pp. 89-92. Joan Robinson's remarks in the introduction of the quoted work are helpful to clear up this issue.) Of course, "expanded reproduction," the only feasible alternative, means acceleration. Viz. human experience to date is not conducive to imagining a world of zero economic/population growth.

[40] Fullbrook (2012) is an excellent example.

[41] Economic consultants making these upbeat (time-symmetrical) projections have developed a devilishly clever language game. They use words such as "risks," "challenges," and "opportunities" to erase the specter of insurmountable limits to growth.

to go from opprobrium to acceptance?" is "a new *chaotic transition*;" that is, an *ex ante* impenetrably *extempore* search for a new global steady state.

One of the most fascinating and mystifying aspects of *chaotic transition* is what scientists and philosophers call "emergence:" Qualities in the newly emerged system could not be deduced by investigating the individual components that made up the original system. Who would have thought in 1914 when the world declared war on itself that out of seemingly endless hecatombs and unimaginable suffering; hopeless efforts to restore GS1 and huge false starts (communism and brutal attempts by two industrialized countries to subjugate the rest of the world) a global order of consumer capitalism organized along the principles of the American New Deal, side by side with the comforting presence of the United Nations, would appear in 1945?

We can recognize in "1914-1945" the three general phases of a successful bifurcation: spontaneous symmetry breaking, experimentation, and resolution. Thus, world history reflects the general principles of discontinuous transformations with emergent properties. Such transformations have been observed in the inorganic world, in biology, and in social organizations (on a lesser than global scale). A few examples follow.

Snowflakes: In the conversion of low temperature vapor to snowflake crystal (a stronger, more structured material organization with six-pointed symmetry), chance vibration at the molecular and atomic levels frustrates predictions of the three phases of chaotic transitions, even when control parameters (such as temperature and humidity) are well known and precisely measured.

Magnetization: Similarly, human insight is limited in foreseeing the emergence of higher order in a piece of iron that is being cooled. Above the *Curie point* the atoms vibrate wildly; below it they calm down. As the shuffling subsides, internal forces of negative and positive poles find an arrangement resembling a latent magnet along a North-South axis. But before this happens, they have to sort out their own attractions and repulsions. For a fraction of a second, all the tiny domains must be confused. They do the inorganic equivalent of "which way should/could I turn?" as they try to settle into a collectively more comfortable energy state. Individual atoms involved in mass action cannot possibly be programmed by Nature to adapt positions and angles so as to be latent magnets, ready to respond to external magnetic attractions. The size of the iron, its external conditions, the speed of heating, the level of purity and variety of concentration all influence the modality of coming to a new, stable internal arrangement. The information allowing order to be established develops through a spontaneous, experiential tumult -- trial and error.

Slime mold (Dictyostelium discoideum): It hangs around as a carefree, highly individualistic heap of single-celled units until the physical environment becomes less hospitable and low entropy turns scarce. At that point the ranks seem to be confused, but

an extreme social cohesion soon emerges in the form of a single organism that crawls across garden floors, gobbling up rotting leaves and wood in its path.[42]

Fetus: Thirty-eight weeks following fertilization, the inner mass of identical cells begins the radical elaboration of future organs. Of course, we know by now that the information required to create structural and functional subsystems resides in the DNA. However, heredity's aperiodic code must overcome an unsurveyable opulence of atomic-molecular disorder. From a profusion of chance and fragmented micro-endeavors emerges the grand design of human organism and consciousness.

Hawaiian Creole: As described by Talbot (1988), "Creole" is the generic name given to a language that develops when dominant and subordinate groups speaking different pidgins live in prolonged contact. In 1875, when the United Sates signed an agreement with the Hawaiian monarchy, the sugar industry in the islands began to boom and labor poured in to work on the plantations. Attempts at simplified communication in rudimentary Hawaiian, Korean, Japanese, and Spanish mingled with the overseers' English. Sometime during the turn of the last century, the first generation of native children began to speak an entirely new language, complete with its own grammar and syntax. Although it borrowed words from all of the tongues represented in the original Babelian melee, it was incomprehensible to immigrant adults, including the English-speaking plantation owners. Even more surprisingly, the Hawaiian Creole's grammar and syntax are similar to those of hundreds of other Creole languages around the world, even though their vocabularies are entirely different (ibid).

Organizations: Modern management science has connected discontinuous transformations in business firms (e.g., as a result of facing bankruptcy) to chaos theory. In such models, bifurcation is manifest in discontinuity, the working ground from which a new stable configuration transpires after an indeterminate period of clashes among proposed solutions, internal power groups, and influential individuals.[43]

Chaotic transition on the global scale is just as natural and inevitable as in the above-quoted examples. The difference is that the world's metamorphosis is comprehensive without a residue (i.e., there is no subject that would not also be an object of the process) and its duration, as demonstrated by historical experience (1789-1830s; 1914-1945) is

---

[42] For details, see the study of Garfinkel, A., "The Slime Mold Dictyostelium as a Model of Self-Organization in Social Systems," in Yates (1987).

[43] Cf. DeShon and Svyantek (1993); Dooley and Johnson (1995); as well as Leifer, R., "Understanding Organizational Transformation Using a Dissipative Structure Model:"

http://hum.sagepub.com/content/42/10/899.short

See also Thiétart, R.A. and Forgues, B., "Chaos Theory and Organization:"

http://orgsci.journal.informs.org/content/6/1/19.abstract?ijkey=57e74557b452783ee20f31b767bfff3abb8b5ecf&keytype2=tf_ipsecsha

measured in decades. For these reasons it is analytically and morally difficult to accept that descriptive history, with its leading personalities and fateful events, is nothing but the verbal distillation of a thermodynamic (physical) dictum: the world "rethinking itself" by going through a brainstorm, as it were; living through a period of disequilibrium that systemlessness brings in its wake.

Chaotic transition is near when the established order becomes prone to disruption through stochastic developments. This characterization corresponds to the "butterfly effect" as initial condition sensitivity has been nicknamed in the study of nonlinear dynamics. How an innocuous and totally unpredictable small event on the molecular/atomic level escalates in significance may be illustrated by the assassination of Archduke Francis Ferdinand, heir apparent to the Hapsburg throne, in Sarajevo, on June 28, 1914.

Through tragicomic events, the conspiracy of young Serbian nationalists came very close to a ridiculous failure.[44] But just when the whole thing looked like a youthful blunder, randomness came to the aid of Big History.

One of the conspirators, Gavrilo Princip, who skipped dinner the night before, got hungry and decided to sample the offerings of Moritz Schiller's delicatessen downtown. In the meantime, the Archduke insisted on going through with the originally scheduled program, even extending it with the PR gesture of visiting the military hospital where the victims of the earlier bomb explosion were treated. General Potiorek, the governor of Bosnia-Herzegovina, decided to speed up the convoy by taking the unencumbered, freeway-like "Appel Quay" along the river. He informed everyone about the route change except the chauffeur of the car in which he sat with the royal visitors. The conveyance ended up alone in the narrow downtown street where Schiller's establishment was located.

The General yelled, the chauffeur stopped and began to back up as a crowd of onlookers gathered. Gavrilo, now in the front of the restaurant, found himself face to face with his targets. He pulled out his pistol and killed the Archduke and his wife. As is well known, the ensuing chain of diplomatic events led to the thundering "Guns of August" and the curtain fell on GS1. The *chaotic transition* began.

It is hard to see the "from insignificant to significant" paradigm of escalation in this event. In order to find the real innocuous, totally unforeseeable occurrence (inviting even the notion of being external to human affairs as these are presumed to be observable by the naked eye), we must enter the brain, the neurophysics of forming thoughts, making determinations, and instructing the body to carry them out.

[44] One of the conspirators threw his bomb. Hearing the explosion, he dutifully bit into his cyanide capsule and jumped into the nearby Miljacka River. What he did not know was that the bomb bounced off the Archduke's car and exploded under the next one; that the cyanide was years past its "expiration" date, and the river that was expected to swallow him was about three inches deep at that time of the year. The rest of the conspirators did not act. They either thought that the deed was done or became paralyzed in the critical moment.

Superficially, it may appear that the nearly infinitesimal material conditions that led to GS1's demise resided in the random coincidence between two electrochemical events: One that signaled hunger for the assassin (especially for the offerings of Herr Schiller) and the momentary forgetfulness of the General to instruct his driver about the change of route. Of course, the proposed explanation is more complex and comprehensive: When GLOPPE's scheme of self-organization becomes obsolete, the minute probabilities of random, insignificant events (each capable of starting a fatal chain reaction) accumulate to a level where system failure becomes a physical inevitability or, using the customary sociological term; a historical necessity. This view of the world connects irregularities with regularities, the chance variations in the subatomic universe (the infinite number of Brownian movements of particles in GLOPPE) with easily comprehendible causalities.

Since the thermodynamic take of history tells us that a critical transformation in the global system must occur in order to rectify GLOPPE's untenable relationship with its ecological constraints, our world is pregnant with a new *chaotic transition.*

The socially destabilizing effects of stagnation, combined with widening income differences within nations, the insane expansion of credit (implying enhanced bubble risks);[45] the euro crisis (Boyer, 2013), the U.S. debt crisis (Pollin, 2012), and sharpening conflicts over resources represent thousands of catalysts to make the famed butterfly flap its wings. In short, while it is clearly impossible to foretell time, location, and the modality of the GS2-disrupting chain reaction, the certainty of its nearness weighs heavily on our generation.

The recognition that the difference between GS1 and GS2 was much smaller than between GS2 and GS3 gives one pause. If it took "1914-1945" to accomplish a relatively small transformation, what will it take to develop a working consensus on the institutional parameters and correlate personal behavior for a drastically different form of global self-organization?

Only the proffered intensity of the need to find a solution brightens the horizon.

Seventeenth-century philosopher Thomas Hobbes argued for the importance of the state. Without its power to tame interpersonal competition, he said, life would be "solitary, poore, nasty, brutish, and short." (Hobbes, 1952 reprint, p. 97.) We may add a vital corollary to his insight: The state can remain effective only if its scope and methods change with GLOPPE's growth, which is obviously not a mere swelling but also a progression to ever higher modes of self-organization. Unless the state reappears in a

[45] The stock of global credit increased from $57 trillion in 2000 to $109 trillion in 2009 and (barring a global *Krach*) it is expected to reach $210 trillion by 2020:

http://www3.weforum.org/docs/WEF_NR_More_credit_fewer_crises_2011.pdf

Vasco and Gabaix (2013) have found that the expansion of the financial sector has been a major factor in the recent rise of macroeconomic volatility.

new, updated form on the world's stage, sometime later in this century, the law of the jungle will grab *Homo sapiens* by its throat.

Further investigation is premised upon a link between universal history (including social and economic history) and the temporal succession of consciousness structures.

6. Diachronic momenta of consciousness

6.1. Consciousness as "differential totality"

In a narrow sense, when it is directly connected with cerebral activities or conditions; i.e., when it has a demonstrable physical basis, consciousness is "differential totality." It contains all the information necessary to deal with the most burning problems that the physical-social-cultural-economic environment presents for the individual. The adjective "differential" is meant to draw attention to the circumstance that consciousness is made up of active and passive components. The first category comprises those perceptions and memories that have an immediate bearing on adaptation, on the quest of rewards; as well as on information about feasible alternatives to carry out related activities. The second category contains all other information pertaining to individual existence. The separation is not rigid. Consciousness is best visualized as a continuous spectrum that stretches from the body's biological processes, which remain unconscious unless attention is explicitly drawn to them (e.g., in the doctor's office) to crisis in the family, at the workplace, or in the environs otherwise delineated.[46]

In the age of global self-organization, the second category includes neuro-chemical imprints of the global-system-specific "rules of the game:" the local application of internationally comparable institutions along with the principles and modalities governing intersubjective relations. During a *chaotic transition*, the world is split into antagonistic subfields; viz. the conflict-ridden difference in the "rules of the game" based upon which the individual had to seek survival or differential success in the United States, the USSR, and Nazi Germany during the 1930s.

The passivity of our knowledge about enduring socioeconomic conditions is tantamount to the objectification of human relations, to the provenance of what Georg Lukacs called man's "second nature;" an extension of eternally valid laws of being (e.g., the circadian rhythm, the way waves break on the seashore) to reified institutions. What people living under a stable global system consider "true assertions" about history, society, and the economy presupposes a scaffolding of the conceptual universe that the mind tends to conflate with the laws and regularities of the natural world.

Of course, no "second nature" can be eternal. Cultural evolution is, in fact, a story about creating, maintaining, and getting rid of "second natures."

[46] Schrödinger (1967, pp. 99-109) inspired this paragraph.

Stated differently, "objectivity" is a historical category. It shifts over time, not only in the natural sciences but also in socioeconomic relations. We can say with Hegel that real is rational and the rational is real but, of course, the real moves while it is human nature to believe that the conditions of the day are everlasting. The implied inevitability of chaotic interludes separating relative steady states conforms to the proposition that GLOPPE is a spontaneous, far-from-equilibrium, dissipative process.

The widely accepted recognition that individual consciousness is inseparable from its socioeconomic substratum did not come easily. Ever since the 17th century, when René Descartes fathered modern dualism by drawing a sharp dividing line between *res cogitans* and *res extensa*, philosophers have struggled to reunite the two. "Mind and society are two aspects of the same evolutionary process" argued Giambattista Vico already in the first half of the 18th century (Schumpeter, 1954, p. 137). Much more was to follow through the contributions of Kant, Hegel, Marx, Husserl, the psycholinguists, the existentialists, the structuralists and the postmoderns.[47]Yet, you can peruse contemporary economic literature without finding an admission that, to a large extent, we see economic life with its laws and history not as it is but as we are; complex products of a world order. The need for adaptation at the species' scale will bring drastic changes. In the realm of theorizing, creative sensitivities will renew the "historical school," which, as the counter pole of GS2 economics, disintegrated after the collapse of GS1.

6.2. Gebser

The importance of Jean Gebser regarding the philosophical schism that separates dualism from a complete inseparability between the individual's internal and external worlds (i.e., the self with its "thinking thing" and the surrounding socioeconomic milieu) resides in advancing the notion of *integral-arational* consciousness.

Gebser's archeology of consciousness identifies five patterns, structures or mutations: The *archaic* (the first one to emerge from the "origin" was marked by instinct and presentiment); the *magical* (characterized by a pre-conceptual; pre-symbolic, vital life-feel); the *mythical* (cohesive apprehension through pre-egoic polar thinking); the *mental* (spatial, dualistic, conceptual, system-building, synthesizing, abstract comprehension); and the *integral-arational*, which transcends, unites, and balances all previous structures. Gebser argued that the structures remain co-present over time. Thus, a subsequent phase does not replace the previous one; rather it "overdetermines" it, thereby creating a cumulative complexification that will become transparent only when the typical individual (i.e., global society) embraces *integral-arational* consciousness.[48]

---

[47] Edmund Husserl (1859-1938) is credited for the explicit break with Cartesian dualism and for the overflow of positivism it inspired. By directing attention to the "subject" and "consciousness," Husserl exerted a crucial influence on 20th century philosophy. Cf. Stewart and Mickunas (1990).

[48] For more complete descriptions of Gebser, see Combs (1996) and Feuerstein (1987). The ultimate source is, of course, Gebser (1975 and 1984). The second date refers to *The Ever-Present Origin* as rendered brilliantly into English by Noel Barstad and Algis Mickunas. Although the subject is not relevant in the current context, it needs to be strongly underscored that consciousness meant a great deal more for Gebser than what physicalist "brain science" can tell us.

Only states of mind that arise from *integral-arational* consciousness are capable of accommodating the seemingly antithetical convictions that (a) an individual, or a group of identically thinking and motivated individuals (i.e., a socially defined *genus*), may make an independent and objectively relevant assessment about society and history; and (b) that all such assessments are stamped by the prevalent global system and, in case they point beyond it, i.e., represent blue prints for the next world order, they could not be implemented through transformations that one commonly associates with reforms and political program. (Just remember what it took for GS2 to come into existence!)

How right F. Scott Fitzgerald was when he said that intelligence is the ability to accept two contradictory ideas and still function. The intelligence he referred to is not a high IQ or some remarkable analytical or artistic talent; it is the faculty of leaving certain competing ideas, whether they are scientific propositions or articles of faith, nonconflated and unbrokered. It is the readiness to tolerate a conundrum without dialectical resolution or relegation of the whole problem to the waste basket -- it is *integral-arational* consciousness in practice. But let us return to the socio-historical perspective to see for what other reasons (besides striking a mental-psychological balance between voluntarism and fatalism) *integral-arational* consciousness is humanity's teleological attractor.

Each consciousness structure coincided with distinctive socioeconomic conditions: The *archaic* with primitive hunting, fishing, and gathering; the *magical* with more advanced versions of the same activities within increasingly complex social schemes centering on the horde; the *mythical* was characterized by agriculture; and the *mental* by industry coming to dominance. The *mental* structure can be traced to ancient Greek philosophy in an era marked by a spurt in the development of handicrafts, shipbuilding and the geographic expansion of trade.[49]

Consciousness structures go through an efficient and a deficient phase, according to Gebser. He considered rationality (with its offspring of vulgar materialism) the deficient form of mental consciousness, dating its reign to the second half of the 18th century when, propelled by the English industrial and the French social revolutions, the world's first *chaotic transition* began, settling in GS1. Time "broke forth," Gebser argued, meaning both the constant and growing preoccupation with time and its spatialization (e.g., the positive-feedback-loop-like, self-multiplicative spread of flowcharts, schedules, and plans, turning time into a divisible quantity marked off along an axis), to the detriment of individual wholeness.

The growing deficiency of mental-rational consciousness may be observed in the age of global systems. GS1 required masses of parsimonious, placidly obedient, beaten-down philistines. Hašek's "good soldier" Schwejk and Büchner's Woyzeck illustrate the absurdity and tragedy of the resultant deformation of individual consciousness. But as soon as the system became ensconced, rebellion against it was born, growing in intensity; from Melville's "scrivener" Bartleby to Stone's Eugene Debs, the socialist labor organizer ("Adversary in the House"). The GS1-typical persona was straining toward its

[49] The often quoted gem of Protegoras: "man is the measure of all things" (uttered two-and-a-half millennia ago) was one of the first documented manifestations of mental consciousness (Gebser, 1984, p. 77).

GS2 avatar; the insatiable consumer with a mortgage and assorted credit cards. The implied transformation makes perfect economic sense. The "accelerate or collapse" Archimedean point of our global system could not exist without a personality that displays "The better I live, the more I demand!" as its permanent marquee.

From a Gebserian standpoint, the worsening deficiency of mental-rational consciousness (expressed through imputing a quasi-divine status to rationality) is organically tied to the historic breaking forth of integral-arational consciousness.

6.3. What is wrong with rationality?

The public at large, unfamiliar with Gebser, is taken aback upon hearing criticism of rationality. It sounds like a blanket rejection of analytical matter-of-factness in diagnosing personal, business, or social problems. "What is the alternative: irrationality?"

Gebser was aware of this reaction and made it absolutely clear that he did not equate *ratio* with understanding or with common sense (Gebser, 1984 -- henceforth EPO -- p. 95). Rather, he used the concept in accordance with the word's original Latin meaning: to reason by comparing magnitudes. He criticized rationality (the general practice and adulation of the *ratio*) for its proclivity to subdivide complex phenomena into partitioned sectors; to view the world through narrow perspectival slits with an exaggeratedly quantitative emphasis (EPO, p. 93). Syntheses built on this approach result in rigid, disconnected systems that have little to do with the fullness of reality.

Rationality so interpreted is complete with an axe-grinding advocacy of whatever limited angle of observation the individual represents. Gebser showed that the progressive strengthening of this method is destructive (EPO, pp. 96 and 97) as it reduces comprehension to "amorphous nullity" (EPO, p. 180), leading to "rational chaos" (EPO, p. 303). And, of course, the sequel to rationality is not irrationality but intensified consciousness (EPO, p. 480); integral comprehension.

Let us repeat: By rationality Gebser meant the exaggeration and the ultimately untenable, senseless pushing of a good thing.

How well contemporary economics confirms Gebser's misgivings may be seen in (i) the reduction of individual motivations to hunger for consumption and the accumulation of material wealth; the brassy advocacy of private interests harmful to the public; (ii) blatant a-historicity; (iii) narrowly perspectival analytical propositions to deal with the looming physical constraints to economic growth; (iv), the "objectivation" of market prices; and (v) absence of the integral view.

(i) In the name of rationality (taken as a synonym for reason), run-of-the-mill economics has demoted *Homo sapiens* to *Homo oeconomicus*; a software code with the intelligence level, emotional universe, and intentionality of a web search engine. (For a detailed explanation, see Dopfer, 2005, pp. 21, 22, 27, 28, 29, 33, 41, 371, *et passim*.) This simplification has lent itself to a dazzling variety of attempts to describe the economy as

a super-temporic, self-perpetuating circular-motion mechanism. The "rational expectation hypothesis" (REH), which connects traditional (GS2) economics with the mental habit of chopping and slicing reality, then building blind syntheses on the lifeless residual of inorganic monads, is "Exhibit A." By equating the economy's temporal change to a data-generating process, REH assures the world that, as long as the players are permitted to be rational (i.e., get the government out of the way of private business!), economic growth will remain on an even keel (at least stochastically).[50]

Under the guise of opening the arena for the rationality of market forces, domestic and international finances have been deregulated with the simultaneous instauration of jaw-dropping bonuses to capital market operators. That such a combination has the rational consequence of serial bubble creation; spreading fraud through the economic and political system can hardly be turned into a *kudo* for "rationality." The whole effort to construct an aura of omniscience around this concept is nothing more than a fancy ideological plug that exaggerates the social service potential of unchecked greed.

(ii) Rationality-flattened reality has turned history into the history of how the primordial forces of the market have accommodated the timeless human expediency to maximize profits and consumption. Rationality-infected historiology denies the temporal relativity of socioeconomic arrangements; its votaries see present society and its antecedents through neoclassical utility and production functions. Accordingly, the past is best described by recognizing the proto-variants and primitive manifestations of today's market-oriented behavior, social interactions, and legal-institutional framework. The favored approach to economic history resonates with the French adage*: plus ça change, plus c'est la même chose.*

The critically acclaimed work of Reinhart and Rogoff (2009) is a fair specimen of this overwhelming tendency. It is openly motivated by a kindred mantra: "We have been here before." The study is thoroughly researched and elegantly presented. But this hardly exonerates first-rank scholars from the folly of equating numerous sovereign and banking crises since the infancy of capitalism based on a limited number of unhistorical characteristics. (The text explaining the condemnation of Galileo could hardly be faulted for its Latin.) Self-feeding speculative episodes ending with spectacular disruption may have always been driven by the prospects of personal gains, corporate miscalculation, and political survivorship; they may have always been marred by manipulation, gullibility, and inertia in mass behavior, but they have differed essentially in the form and substance of their impact on the evolving individual as a social component, on the constantly transforming national economies and on international economic relations.

Accelerating demographic and economic growth has been a relentless novelty producer. Consequently, the world changes beyond the control of mind and will, sweeping along personal lives and reasoned judgment. The *cogito* is inundated with so much new information that believing that "this time is different" is par for the course because in so many different ways it really is.

[50] Syll (2012) puts REH in its place.

"This Time is Different" conjures up a fictitious gambler who plays the same game for eight centuries. The inebriated idiot is either inflicted by a chronic gambler's fallacy, culminating in sequential Martingale fiascoes (given that output and stakes have grown over time); or he has neglected Bayesian derivations, or again, he has been using consistently wrong evidence to update his beliefs.

Deemphasizing the multifaceted variance among selected events negates the fundamental dynamism of universal history; the crucible of finding, maintaining, and renewing order amidst the unstoppable expansion of the human biomass and produced, extrasomatic structures. But this is exactly what a living global system wants to hear and is bent on rewarding: "I will always be because I have always been!" Its best strategy of self-preservation may well be to keep the unidirectionality of history off discourse: Don't talk about global systems as broadly distinct phases! The meta-sociological blinders that GS2's *text* has welded into the minds of postwar generations may be blamed for such ludicrous propositions as "let's bring back the gold standard" and "let's reject Keynes in favor of Adam Smith;" or, to argue with equal futility for "Keynes" in the false belief that reified institutions could be declared null and void through coercive grandstanding. The same insensitivity is detected in using "we" as the almighty voluntarist decision-maker capable of stamping out pollution, making electrical cars dominate the highways, and ending our "addiction" to oil. Such "we"-predicated propositions tacitly assume an *ad libitum* political control over the global system's parameters or they do not recognize the existence of these parameters at all.

(iii) An example: Two eminent energy experts, M.Z. Jacobson and M.A. Delucci, estimated that a comprehensive strategy to shift the world's energy basis toward renewable sources would require about 3.8 million wind turbines. (See "A Plan to Power 100 Percent of the Planet with Renewables" in the November 2009 issue of the *Scientific American Magazine*.) But, according to André Diederen (senior scientist at the Netherlands-based research institute, *TNO Defense, Security and Safety*) the manufacture of that many large (5 MW) wind turbines would demand roughly three million tons of Neodymium. The current annual production is 18,000 tons and Lenntech (an associate organization of the Technical University of Delft in the Netherlands) puts global reserves of Neodymium at eight million tons.[51]

A total reserve figure does not reveal what proportion of it is economically recoverable (since it is the sum of proven, probable and possible deposits); a circumstance aggravated by the fact that this "rare earth" element is hardly found in pure form, implying that a good chunk of the eight million is too expensive to access. Moreover, unlike the commons (the oceans and the atmosphere), metal reserves are national property. China happens to be the country richest in Neodymium and it has recently imposed controls on the exportation of "rare earth" elements. Even in the extremely unlikely case that three million tons could be produced, how about replacing wind turbines? They don't last forever.

[51] From André Diederen's presentation, entitled "Materials Scarcity and the Elements of Hope," at the *Bioneers Global Conference*, May 31- June 1, 2010, Driebergen, the Netherlands.

The obstinate advocacy of nuclear, geothermic, hydroelectric, and solar power; natural gas, bio-fuels; and, as mentioned above, nanotechnology, reeks of similar deficiencies.

Concerning the reversal of environmental degradation, neither the demonstrated ineffectiveness of the parochial national (or even subnational) approach, nor the hopelessness of dealing with the world's environmental problems by leaning on the profit motive provokes a tocsin in rationality-ruled mental consciousness. The piecemeal approach to emission controls will not generate planet-wide virtuous circles and private business will always choose profit over reducing pollution as long as the regulatory vacuum permits it.[52] As Professor Nicholas Stern stated, "Climate change is global in its origins and in its impacts. An effective response must therefore be organized globally and must involve international understanding and collaboration" (Stern, 2008, p. 26). This is certainly true, but the global approach will have to wait until GS3 transposes GS2 rationality.[53]

(iv) The unwillingness to see GLOPPE as a spontaneous bio-social configuration explains why market prices do not account for the entropic process that mercilessly shadows the world. The valuation of commodities simply cannot reflect the *Drawdown* if the average mind ignores it. Claiming the contrary is rooted in the drastic overreach of rationality-dominated social science that blows out of proportion the empirically undeniable, but ultimately limited subject-object dualism (i.e., the range of influence any individual may exert upon the robust, institutionally-embodied, coordinative structure of interpersonal relations).

The equal validity of supply/demand relations to every economic agent does not mean that prices have an independent ("objective") existence outside our consciousness. Prices may well account for all the factors that billions of linked consciousnesses consider relevant in our era, but for nothing more.[54] And when this web evolves as a result of the anticipated wide-scale recognition of the Earth's *de facto* thermodynamic conditions, the resource cost-core of prices[55] (especially of large, expensive durable goods) will likely

[52] Niven and Rausch (2013) concluded that supply elasticities for fossil fuels would have to be infinite (or nearly infinite) to generate net negative emission leakage. (Of course, infinite supply elasticity for an omnipresent input is an absurd condition. It implies that even a Planck-length displacement of the price would disrupt the economy.) The investigation's main conclusion seems to be absolutely correct: "Leakage estimates from CGE models are unlikely to be negative." Examining the effectiveness of methods to improve air quality in California, Auffhammer and Kellogg (2011) confirmed that the no-nonsense, strong ("inflexible") approach is superior to leaving the choice of compliance mechanism in the hands of private business (refineries in the article's context) in order to minimize interference with profit maximization.

[53] Using a global CGE model, Timilsina and Mevel (2013) showed that unless forest lands are spared in efforts to achieve national biofuel production targets by 2020, greenhouse gas emissions owing to land-use change would exceed the reduction attributable to substituting biofuels for gasoline and diesel. This result supports the argument that a stronger global approach than what GS2 can deliver will be needed to address issues of sustainability on the planetary scale.

[54] The ecological economic model of Takuro Uehara (2013) demonstrated that market prices do not reflect the boundaries of an ecological system.

[55] I.e., prices that abstract away from supply and demand; or, alternatively, a quantitative remainder when their interplay is negligible. GS2 economics does not recognize the existence of such a quantity. Its maxims claim that prices arise from dynamic, equilibrium-seeking interactions among ratios. Samuelson considered prices "Langrangean multipliers" (Samuelson, 1948, p. 231); evidently needing a comprehensive equation

include an explicitly articulated awareness of the entropic principle, although right now it is hard to imagine seeing a "calories per Kelvin" coordinate in economics textbooks.

(v) An integral assessment of the world economy (in combination with the thermodynamic perception of history) may sound like this: The continued expansion of GLOPPE inevitably aggravates resource and environmental problems (e.g., the marginal cost of nonrenewable resources has embarked on a long-run tendency to increase;[56] global pollution and world output are positively correlated). Instead of stimulating growth to a significant extent, measures to boost market confidence in the current ruptured state of GS2 only enhance banking power and push governments toward the unpalatable choice between fiscal default and loosing their sole tool to ameliorate the consequences of income differentiation, which become progressively worse as a result of stagnation. Of course, given the role of the U.S. dollar as the source of international liquidity, the *lingua franca* of international economic relations; the "choice" is extremely limited: The size of U.S. debt and the size of the world economy are also positively correlated. (The political turmoil and deadlock surrounding fiscal deficits is the only logical response to this systemic no-exit situation.)

"Rationality" (as a philosophical doctrine *cum* methodology) inspires the separate investigation of the above-mentioned issues, denying their organic totality. But its critique ought not to stop at simply negating the validity of this orientation, as if positing an antithesis. The integral approach demands the recognition that the enormous volume of high quality, varied economic analysis performed in compartmentalized subfields helps lay the foundations for a future, *truly* global approach to global problems.

6.4. Consciousness and the new world order

What will the parameters of a warranted new global system be? Regardless of how rightly or wrongly "GS3" may characterize it, any consistent attempt to think through the answer must conclude that a radically new social, economic, and political organization will be needed to deliver the world from itself.

"Ay, there is the rub..."

---

system to be calculated. Debreu emphasized that prices are void of any intrinsic appurtenance (Debreu, 1959, p. 33). Nor is the implied residual a labor input in the Marxian sense. It cannot be because Marx himself drifted from his original labor theory of value (which stipulated absolute numbers) toward embracing ratios. (Robinson effectively summarized this contradiction between volumes I and III of *Das Kapital*. Cf. Robinson, 1962, p. 39.) Thus, the above expression "quantitative remainder" is "undoctrinaire" as it implicitly refers to a theory of value yet to be invented. This proposition is less vague than it first appears if one is mindful that the "rationality" of consumers and producers, which is invoked in determining prices in current economic theory, is based on the world's fallacy of composition regarding thermodynamic openness, a collective illusion that promotes the lethal dogma of endlessly accelerating material bounteousness.

[56] Renewable substitutes will not eliminate this problem. For example, "green" electricity is clearly more costly than electricity generated from traditional (nonrenewable) sources. Cf. Borenstein (2012).

The difference in institutional terms between GS3 and GS2 is so significant that bridging it is impossible without envisaging a major transformation of individual consciousness; yet, the average individual would not -- could not! -- be inwardly transformed as long as socioeconomic institutions characteristic of GS2 prevail. Patterns of behavior, thoughts and feelings ("BTF," as psychologists who often use this trinity refer to it) have become crystallized around the GS2-typical comprehension of the world.

The unfolding collision between our civilization and its ecological constraints, along with a historic crisis of epic proportions, may be regarded as the struggle of integral-rational consciousness to deprive overblown rationality from its current dominance. One may guess that the emergent consciousness will favor cooperation over competition; acquiescence over indifference; responsible sociability over isolation; integrative open-mindedness over stubborn, perspectival dogmatism, altruism over extrasomatic hedonism.[57] But who could tell what it will take to turn today's world into a new enlightened one of enhanced global solidarity?

Chaotic transition is not our best friend but there seems to be no other solution than to wait for the broom of history to sweep away the world's unsolvable and growing disharmonies, making space for the experiential spasms that *perforce* develop in the wake of clashing ideas, interests, and passions.

"The germinal phase is the crux," said "I Ching," the Chinese book of changes, a long time ago. Only one certainty remains: Regardless of how much adversity, sacrifice, and misfortune the impending tumult of renewal will impose on countless lives, future historiography will subsume all that into the ethos of a new age, recounting the emergence of the "One World" from the twilight of a dangerous phantasm; from an inferior, self-augmentation-infused comprehension of the human journey.

7. Concluding remarks

(1) During the past hundred years the world learned that the state cannot plan economic growth to satisfy individual wants. In the current century, it will have to learn that *bona fide* sustainability and the limitless growth of consumption are antinomic. For most firms (i.e., for the foundation of the global economy), movement toward a renewable resource base and pollution control will not prove to be good business.

(2) The acknowledgment that the totality of activities has a scale limit is understandably slow because economic developments are evaluated in the conceptual and quantitative terms of a system that repudiates the existence of such limits. Nonetheless, a trickle of information about binding resource constraints and the system's doctrinaire incapacity to recognize them has begun to seep into public discourse.

[57] Altruism of individual organisms directed at a group (in the animal kingdom, in general) can evolve by natural selection, according to Edward O. Wilson (Wilson, 2000, p. 87). In the concluding chapter of the quoted tome, Wilson convincingly argues that humanity's ecological steady state may well favor altruistic genes.

For example, the proposition that skyrocketing oil prices triggered the Great Recession (rather than, as is widely believed, the bursting of the housing bubble for the sheer reason of over-extending credit) has gained some traction. It is indeed highly plausible that the fuse of the turmoil-provoking explosion was lit at a gas station/grocery store somewhere along the interminable commuting route between a North American city, where the jobs are, and exurbia, where the zero-down-payment houses were built and sold on the assumption that the costs of transportation and food would never interfere with the perpetual climb of real estate values.

The trickle is bound to become an eddy; then a cascading maelstrom, as it is discovered that real growth has slipped under Nature's control. It is telling that instead of restarting significant acceleration, the continued buildup of public debt and digital money only makes asset bubbles blossom like mushrooms after the monsoon. To paraphrase Bertolt Brecht, the bitch that bore the monster of rising oil prices causing economic dislocation via financial havoc "is in heat again."

(3) Unless *Homo sapiens* can break out from its sublunary cradle, it will find itself in an evolutionary dead-end, uglified by featureless Gorgon heads. Sending mining robots to the Moon and terraforming Mars (i.e., making the Red Planet more earthlike through modifying its ecology) are the most frequently quoted ways to capture extraterrestrial matter/space. This is the only type of permanent, unlimited expansionism capable of preserving man's Faustian will in the gloriously rugged spirit of seafaring discoverers.

8. References[58]

Auffhammer, M. and Kellogg, R. (2011), "Clearing the Air? The Effects of Gasoline Content Regulation on Air Quality," *The American Economic Review*, vol. 101, no. 6, pp. 2687-2722.

Barro, R.J. and Sala-i-Martin, X. (1995), Economic Growth, McGraw-Hill, Inc., New York, NY.

Borenstein, S. (2012), "The Private and Public Economics of Renewable Electricity Generation," *Journal of Economic Perspectives*, vol. 26, issue no.1, pp. 67-92.

Boyer, R. (2013), "The Euro Crisis: Undetected by Conventional Economics, Favored by Nationally Focused Polity," *Cambridge Journal of Economics*, vol. 37, issue no. 3, pp. 533-569.

Brounen, D., Kok, N., and Quigley, J.M. (2013), "Energy Literacy, Awareness, and Conservation Behavior of Residential Households," *Energy Economics*, vol. 38 (July), pp. 42-50.

[58] Only print and online library items.

Braungart, M. and McDonough, W. (2002), Cradle to Cradle: Remaking the Way We Make Things, North Point Press (Division of Farrar, Straus and Giroux), New York, NY.

Clapp, J. (2001), Toxic Exports, the Transfer of Hazardous Wastes from Rich to Poor Countries, Cornell University Press, Ithaca, NY.

Combs, A. (1996), Radiance of Being: Complexity, Chaos, and the Evolution of Consciousness, Paragon House, St. Paul, MN.

Common, M. and Stagle, S. (2005), Ecological Economics, An Introduction, Cambridge University Press, New York, NY.

Cropper, H. W. (2001), Great Physicists, Oxford University Press, New York, NY.

Daly, H. and Farley, J. (2004), Ecological Economics, Principles and Applications, Pearson and Longman, Delhi, India.

Debreu, G. (1959), Theory of Value, Yale University Press, New Haven, CT.

DeShon, R. and Svyantek, D. J. (1993), "Organizational Attractors: A Chaos Theory Explanation of Why Cultural Change Efforts Often Fail." *Public Administration Quarterly*, vol. 17, no. 3, pp. 339-355.

Diederen, A. (2010), Global Resource Depletion, Managed Austerity and the Elements of Hope, Eburon Academic Publishers, Delft, the Netherlands.

Dooley, K. and Johnson, L. (1995), "TQM, Chaos, and Complexity," *Human Systems Management*, vol. 14, no. 4, pp. 1-16.

Dopfer, K. (ed.) (2005), The Evolutionary Foundation of Economics, Cambridge University Press, Cambridge, UK.

Fermi, E. (1936), Thermodynamics, Dover Publications, Inc., New York, NY.

Feuerstein, G. (1987), Structures of Consciousness, The Genius of Jean Gebser -- An Introduction and Critique, Integral Publishing, Lower Lake, CA.

Fullbrook, E. (2012), "To Observe or Not to Observe: Complementary Pluralism in Physics and Economics," *Real-World Economics Review*, issue no. 62, pp. 20-28.

Gebser, J. (1984), The Ever-Present Origin, Ohio University Press, Athens, OH.

Gebser, J. (1975), Transformation of the West, (in German), Novalis Verlag AG, Schaffhausen, Switzerland.

Georgescu-Roegen, N. (1976), "Energy and Economic Myths" in Energy and Economic Myths: Institutional and Analytical Essays," Pergamon Press, New York, NY.

Georgescu-Roegen, N. (1971), The Entropy Law and the Economic Process, Harvard University Press, Cambridge, MA.

Gillespie, R.J., Humphreys, D.A., Baird, N.C., and Robinson, E.A. (1986), Chemistry, Allyn and Bacon, Inc., Boston, MA.

Ginsburgh, V. and Keyzer, M. (1997), The Structure of Applied General Equilibrium Models, The MIT Press, Cambridge, MA.

Gore, A. (2013), The Future, Six Drivers of Global Change, Random House, Inc., New York, NY.

Gore, A. (2009), Our Choice, A Plan to Survive the Climate Crisis, Rodale and Melcher Media, New York, NY.

Gore, A. (2006), An Inconvenient Truth, The Planetary Emergence of Global Warming and What We Can Do About It, Rodale and Melcher Media, New York, NY.

Hall, C.A.S. (ed.) (1995), Maximum Power, The Ideas and Applications of H.T. Odum, University Press of Colorado, Niwot, CO.

Hobbes, T. (1952 reprint), Hobbes's Leviathan, Oxford University Press, Glasgow, UK.

Jing Chen (2005), The Physical Foundation of Economics, World Scientific Publishing Co. Pte. Ltd., Singapore.

Keynes, J.M. (1965), The General Theory of Employment, Interest, and Money, A Harbinger Book, Harcourt, Brace & World, Inc., New York, NY.

Kolesnikov, I.M., Vinokurov, V.A., and Kolesnikov, S.I. (2001), Thermodynamics of Spontaneous and Non-spontaneous Processes, Nova Science Publishers, Hauppauge, NY.

Kondepundi, D. and Prigogine, I. (1998), Modern Thermodynamics, From Heat Engines to Dissipative Structures, John Wiley & Sons, New York, NY.

Krysiak, F.C. (2006), "Entropy, Limits to Growth, and the Prospects for Weak Sustainability," *Ecological Economics*, vol. 58, issue no.1, pp.182-191.

Lipsey, R.G. and Steiner, P.O. (1975), Economics (fourth edition), Harper & Row Publishers, New York, NY.

Loewenstein, W. R. (1999), The Touchstone of Life; Molecular Information, Cell Communication, and the Foundations of Life, Oxford University Press, New York, NY.

Luxemburg, R. (1968), The Accumulation of Capital, Modern Reader Paperbacks, New York, NY.

Meadows, D. H., Meadows, D.L., and Randers, J. (1992), Beyond the Limits, Chelsea Green Publishing Co., White River Junction, VT.

Meadows, D. H., Meadows, D.L., Randers J., and Behrens III, W.W. (1972), The Limits to Growth, Potomac Associates, New American Library, Times Mirror, New York, NY.

Niven, W. and Rausch, S. (2013), "A Numerical Investigation of the Potential for Negative Emissions Leakage," *The American Economic Review*, vol.103, no. 3, pp. 320-325.

Nordhaus, W. D. (1992), Lethal Model 2: The Limits to Growth Revisited, Cowles Foundation Paper 831; Brookings Papers on Economic Activity, 2; Yale University, New Haven, CT.

Pearce, D.W. and Turner, R.K. (1990), Economics of Natural Resources and the Environment, Johns Hopkins University Press, Baltimore, MA.

Pogany, P. (2012), "Gebser's Relevance to the Global Crisis" in Filling the Credibility Gap, Mickunas, A. and Murphy, J. (eds.), Nova Science Publishers, Inc. Hauppauge, NY.

Pogany, P. (2006), Rethinking the World, Shenandoah Valley Research Press/iUniverse, Lincoln, NE.

Pollin, R. (2012), "U.S. Government Deficits and Debt Amid the Great Recession: What the Evidence Shows," *Cambridge Journal of Economics*, vol. 36, issue no.1, pp.161-187.

Prigogine, I. (1997), The End of Certainty, The Free Press, New York, NY.

Rees, W.E. (2006), "Ecological Footprints and Biocapacity: Essential Elements in Sustainability Assessment" in Renewables-Based Technology: Sustainability Assessment, Dewulf, J and Van Langenhove, H. (eds.), Wiley Online Library.

Reinhart, C.M. and Rogoff, K. (2009), This Time Is Different: Eight Centuries of Financial Folly, Princeton University Press, Princeton, NJ.

Robinson, J. (1962), Economic Philosophy, Doubleday & Company, Inc., Garden City, NY.

Romer, P.M. (1990), "Endogenous Technological Change," *The Journal of Political Economy*, vol. 98, no. 5, Part 2, pp. S71-S102.

Rosser, J.B. Jr. (1991), A General Theory of Economic Discontinuities, Kluwer Academic Publishers, Boston, MA.

Samuelson, P.A. (1948), Foundations of Economic Analysis, Harvard University Press, Cambridge, MA.

Schrödinger, E (1967), What is Life? Mind and Matter, Cambridge University Press, New York, NY.

Schumpeter, J.A. (1954), History of Economic Analysis, Oxford University Press, New York, NY.

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics*, vol. 39, no. 3, pp. 312-320.

Stern, N. (2008), "The Economics of Climate Change," *The American Economic Review*: *Papers and Proceedings*, vol. 98, no. 2, pp. 1-37.

Stewart, D. and Mickunas, A. (1990), Exploring Phenomenology, Guide to the Field and its Literature, Ohio University Press, Athens, OH.

Syll, L. (2012), "Rational Expectations -- A Fallacious Foundation for Macroeconomics in a Non-Ergodic World," *Real-World Economics Review*, issue no. 62, pp. 34-50.

Takuro Uehara (2013), "Ecological Threshold and Ecological Economic Threshold: Implications from an Ecological Economic Model with Adaptation," *Ecological Economics*, vol. 93 (September), pp. 374-384.

Talbot, M. (1988), Beyond the Quantum, Bantam New Age Books, Inc., New York, NY.

Tiemann, M. (1998), *Waste Trade and the Basel Convention: Background and Update*, U.S. Congressional Research Service, Pub. No. 98-638 ENR, Washington, DC.

Timilsina, G.R. and Mevel, S. (2013), "Biofuels and Climate Change Mitigation: A CGE Analysis Incorporating Land-Use Change," *Environmental and Resource Economics*, vol. 55, issue no.1, pp.1-19.

Vasco, C. and Gabaix, X. (2013), "The Great Diversification and its Undoing," *The American Economic Review*, vol. 103, no. 5, pp. 1697-1727.

Wagner, M. (2008), "The Carbon Kuznets Curve: A Cloudy Picture Emitted by Bad Econometrics?," *Resource and Energy Economics*, vol. 30, issue no.3, pp. 388-408.

Wiener, N. (1961), Cybernetics, The M.I.T. Press, Cambridge, MA.

Wilson, E.O. (2000), Sociobiology, The New Synthesis, The Belknap Press of Harvard University Press, Cambridge, MA.

Wilson, E.O. (1999), Consilience, Vintage Books, A Division of Random House, Inc., New York, NY.

Yates, E.Y. (ed.) (1987), Self-Organizing Systems, The Emergence of Order, Plenum Press, New York, NY.